National Semiconductor

April 1998

LP2950/LP2951
Series of Adjustable Micropower Voltage Regulators

General Description

The LP2950 and LP2951 are micropower voltage regulators with very low quiescent current (75 µA typ.) and very low dropout voltage (typ. 40 mV at light loads and 380 mV at 100 mA). They are ideally suited for use in battery-powered systems. Furthermore, the quiescent current of the LP2950/LP2951 increases only slightly in dropout, prolonging battery life.

The LP2950-5.0 in the popular 3-pin TO-92 package is pin-compatible with older 5V regulators. The 8-lead LP2951 is available in plastic, ceramic dual-in-line, or metal can packages and offers additional system functions.

One such feature is an error flag output which warns of a low output voltage, often due to falling batteries on the input. It may be used for a power-on reset. A second feature is the logic-compatible shutdown input which enables the regulator to be switched on and off. Also, the part may be pin-strapped for a 5V, 3V, or 3.3V output (depending on the version), or programmed from 1.24V to 29V with an external pair of resistors.

Careful design of the LP2950/LP2951 has minimized all contributions to the error budget. This includes a tight initial tolerance (.5% typ.), extremely good load and line regulation (.05% typ.) and a very low output voltage temperature coefficient, making the part useful as a low-power voltage reference.

Features

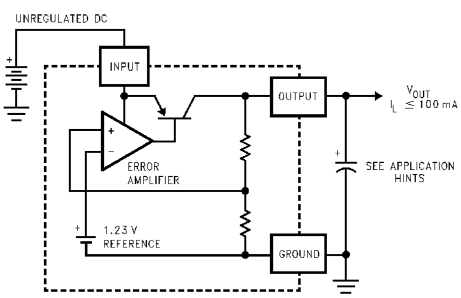
- 5V, 3V, and 3.3V versions available
- High accuracy output voltage
- Guaranteed 100 mA output current
- Extremely low quiescent current
- Low dropout voltage
- Extremely tight load and line regulation
- Very low temperature coefficient
- Use as Regulator or Reference
- Needs minimum capacitance for stability
- Current and Thermal Limiting

LP2951 versions only

- Error flag warns of output dropout
- Logic-controlled electronic shutdown
- Output programmable from 1.24 to 29V

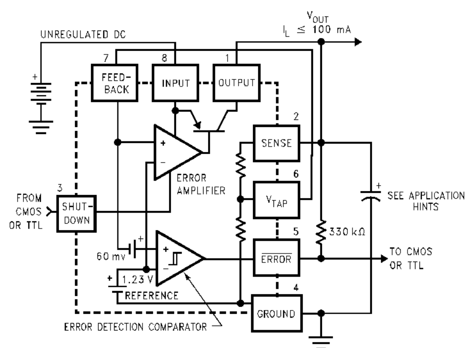
Block Diagram and Typical Applications

LP2950



DS008546-25

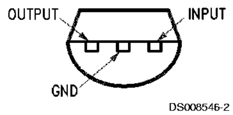
LP2951



DS008546-1

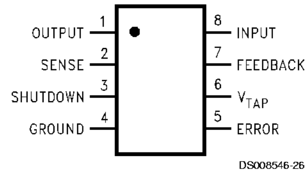
Connection Diagrams

TO-92 Plastic Package (Z)



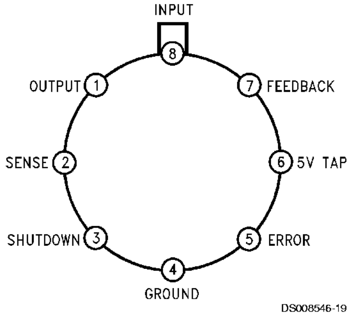
Bottom View

Dual-In-Line Packages (N, J)
Surface-Mount Package (M, MM)



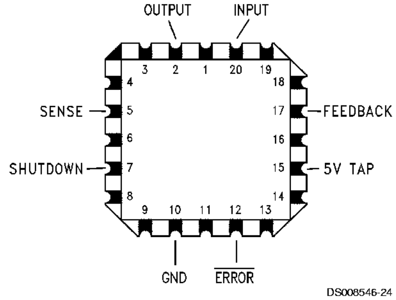
Top View

Metal Can Package (H)



Top View

Leadless Chip Carrier (E)



Top View

Ordering Information

Package	Output Voltage			Temperature
	3.0V	3.3V	5.0V	(°C)
TO-92 (Z)	LP2950ACZ-3.0 LP2950CA-3.0	LP2950ACZ-3.3 LP2950CZ-3.3	LP2950ACZ-5.0 LP2950CZ-5.0	$-40 < T_J < 125$
N (N-08E)	LP2951ACN-3.0 LP2951CN-3.0	LP2951ACN-3.3 LP2951CN-3.3	LP2951ACN LP2950CN	$-40 < T_J < 125$
M (M08A)	LP2951ACM-3.0 LP2951CM-3.0	LP2951ACM-3.3 LP2951CM-3.3	LP2951ACM LP2951CM	$-40 < T_J < 125$
MM (MUA08A)	LP2951ACMM-3.0 LP2951CMM-3.0	LP2951ACMM-3.3 LP2951CMM-3.3	LP2951ACMM LP2951CMM	$-40 < T_J < 125$
J (J08A)			LP2951ACJ LP2951CJ	$-40 < T_J < 125$
			LP2951J LP2951J/883 5926-3870501MPA	$-55 < T_J < 150$
H (H08C)			LP2951H/883 5962-3870501MGA	$-55 < T_J < 150$
E (E20A)			LP2951E/883 5962-3870501M2A	$-55 < T_J < 150$

For MM Package:

Order Number	Package Marking
LP2951ACMM	L0DA
LP2951CMM	L0DB
LP2951ACMM-3.3	L0CA
LP2951CMM-3.3	L0CB
LP2951ACMM-3.0	L0BA
LP2951CMM-3.0	L0BB

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Input Supply Voltage	−0.3 to +30V
SHUTDOWN Input Voltage, Error Comparator Output Voltage, (Note 9)	
FEEDBACK Input Voltage (Note 9) (Note 10)	−1.5 to +30V
Power Dissipation	Internally Limited
Junction Temperature (T_J)	+150˚C
Ambient Storage Temperature	−65˚ to +150˚C
Soldering Dwell Time, Temperature	
Wave	4 seconds, 260˚C
Infrared	10 seconds, 240˚C
Vapor Phase	75 seconds, 219˚C
ESD	TBD

Operating Ratings (Note 1)

Maximum Input Supply Voltage	30V
Junction Temperature Range (T_J) (Note 8)	
LP2951	−55˚ to +150˚C
LP2950AC-XX, LP2950C-XX, LP2951AC-XX, LP2951C-XX	−40˚ to +125˚C

Electrical Characteristics (Note 2)

Parameter	Conditions (Note 2)	LP2951		LP2950AC-XX LP2951AC-XX			LP2950C-XX LP2951C-XX			Units
		Typ	Tested Limit (Notes 3, 16)	Typ	Tested Limit (Note 3)	Design Limit (Note 4)	Typ	Tested Limit (Note 3)	Design Limit (Note 4)	
3V VERSIONS (Note 17)										
Output Voltage	T_J = 25˚C	3.0	3.015	3.0	3.015		3.0	3.030		V max
			2.985		2.985			2.970		V min
	−25˚C ≤ T_J ≤ 85˚C	3.0		3.0		3.030	3.0		3.045	V max
						2.970			2.955	V min
	Full Operating	3.0	**3.036**	3.0		**3.036**	3.0		**3.060**	V max
	Temperature Range		**2.964**			**2.964**			**2.940**	V min
Output Voltage	100 µA ≤ I_L ≤ 100 mA	3.0	**3.045**	3.0		**3.042**	3.0		**3.072**	V max
	T_J ≤ T_{JMAX}		**2.955**			**2.958**			**2.928**	V min
3.3V VERSIONS (Note 17)										
Output Voltage	T_J = 25˚C	3.3	3.317	3.3	3.317		3.3	3.333		V max
			3.284		3.284			3.267		V min
	−25˚C ≤ T_J ≤ 85˚C	3.3		3.3		3.333	3.3		3.350	V max
						3.267			3.251	V min
	Full Operating	3.3	**3.340**	3.3		**3.340**	3.3		**3.366**	V max
	Temperature Range		**3.260**			**3.260**			**3.234**	V min
Output Voltage	100 µA ≤ I_L ≤ 100 mA	3.3	**3.350**	3.3		**3.346**	3.3		**3.379**	V max
	T_J ≤ T_{JMAX}		**3.251**			**3.254**			**3.221**	V min
5V VERSIONS (Note 17)										
Output Voltage	T_J = 25˚C	5.0	5.025	5.0	5.025		5.0	5.05		V max
			4.975		4.975			4.95		V min
	−25˚C ≤ T_J ≤ 85˚C	5.0		5.0		5.05	5.0		5.075	V max
						4.95			4.925	V min
	Full Operating	5.0	**5.06**	5.0		**5.06**	5.0		**5.1**	V max
	Temperature Range		**4.94**			**4.94**			**4.9**	V min
Output Voltage	100 µA ≤ I_L ≤ 100 mA	5.0	**5.075**	5.0		**5.075**	5.0		**5.12**	V max
	T_J ≤ T_{JMAX}		**4.925**			**4.925**			**4.88**	V min
ALL VOLTAGE OPTIONS										
Output Voltage Temperature Coefficient	(Note 12)	**20**	**120**	**20**		**100**	**50**		**150**	ppm/˚C
Line Regulation (Note 14)	(V_ONOM + 1)V ≤ V_{in} ≤ 30V (Note 15)	0.03	0.1	0.03	0.1		0.04	0.2		% max
			0.5			**0.2**			**0.4**	% max
Load Regulation (Note 14)	100 µA ≤ I_L ≤ 100 mA	0.04	0.1	0.04	0.1		0.1	0.2		% max
			0.3			**0.2**			**0.3**	% max

Electrical Characteristics (Note 2) (Continued)

Parameter	Conditions (Note 2)	LP2951		LP2950AC-XX LP2951AC-XX			LP2950C-XX LP2951C-XX			Units
		Typ	Tested Limit (Notes 3, 16)	Typ	Tested Limit (Note 3)	Design Limit (Note 4)	Typ	Tested Limit (Note 3)	Design Limit (Note 4)	
ALL VOLTAGE OPTIONS										
Dropout Voltage (Note 5)	I_L = 100 µA		80		80			80		mV max
		50	**150**	50		**150**	50		**150**	mV max
	I_L = 100 mA		450		450			450		mV max
		380	**600**	380		**600**	380		**600**	mV max
Ground	I_L = 100 µA	75	120	75	120		75	120		µA max
Current			**140**			**140**			**140**	µA max
	I_L = 100 mA	8	12	8	12		8	12		mA max
			14			**14**			**14**	mA max
Dropout	V_{in} = (V_ONOM − 0.5)V	110	170	110	170		110	170		µA max
Ground Current	I_L = 100 µA		**200**			**200**			**200**	µA max
Current Limit	V_{out} = 0	160	200	160	200		160	200		mA max
			220			**220**			**220**	mA max
Thermal Regulation	(Note 13)	0.05	0.2	0.05	0.2		0.05	0.2		%/W max
Output Noise,	C_L = 1 µF (5V Only)	430		430			430			µV rms
10 Hz to 100 KHz	C_L = 200 µF	160		160			160			µV rms
	C_L = 3.3 µF (Bypass = 0.01 µF Pins 7 to 1 (LP2951))	100		100			100			µV rms
8-PIN VERSIONS ONLY		**LP2951**		**LP2951AC-XX**			**LP2951C-XX**			
Reference		1.235	1.25	1.235	1.25		1.235	1.26		V max
Voltage			**1.26**			**1.26**			**1.27**	V max
			1.22		1.22			1.21		V min
			1.2			**1.2**			**1.2**	V min
Reference	(Note 7)		**1.27**			**1.27**			**1.285**	V max
Voltage			**1.19**			**1.19**			**1.185**	V min
Feedback Pin		20	40	20	40		20	40		nA max
Bias Current			**60**			**60**			**60**	nA max
Reference Voltage Temperature Coefficient	(Note 12)	20		20			50			ppm/°C
Feedback Pin Bias Current Temperature Coefficient		0.1		0.1			0.1			nA/°C
Error Comparator										
Output Leakage	V_{OH} = 30V	0.01	1	0.01	1		0.01	1		µA max
Current			**2**			**2**			**2**	µA max
Output Low	V_{in} = (V_ONOM − 0.5)V	150	250	150	250		150	250		mV max
Voltage	I_{OL} = 400 µA		**400**			**400**			**400**	mV max
Upper Threshold	(Note 6)	60	40	60	40		60	40		mV min
Voltage			**25**			**25**			**25**	mV min
Lower Threshold	(Note 6)	75	95	75	95		75	95		mV max
Voltage			**140**			**140**			**140**	mV max
Hysteresis	(Note 6)	15		15			15			mV
Shutdown Input										
Input		1.3		1.3			1.3			V
Logic	Low (Regulator ON)		**0.6**			**0.7**			**0.7**	V max
Voltage	High (Regulator OFF)		**2.0**			**2.0**			**2.0**	V min

Electrical Characteristics (Note 2) (Continued)

Parameter	Conditions (Note 2)	LP2951 Typ	LP2951 Tested Limit (Notes 3, 16)	LP2950AC-XX / LP2951AC-XX Typ	LP2950AC-XX / LP2951AC-XX Tested Limit (Note 3)	LP2950AC-XX / LP2951AC-XX Design Limit (Note 4)	LP2950C-XX / LP2951C-XX Typ	LP2950C-XX / LP2951C-XX Tested Limit (Note 3)	LP2950C-XX / LP2951C-XX Design Limit (Note 4)	Units
Shutdown Input										
Shutdown Pin Input Current	$V_{shutdown}$ = 2.4V	30	50	30	50		30	50		µA max
			100			**100**			**100**	µA max
	$V_{shutdown}$ = 30V	450	600	450	600		450	600		µA max
			750			**750**			**750**	µA max
Regulator Output Current in Shutdown	(Note 11)	3	10	3	10		3	10		µA max
			20			**20**			**20**	µA max

Note 1: Absolute Maximum Ratings are limits beyond which damage to the device may occur. Operating Ratings are conditions under which operation of the device is guaranteed. Operating Ratings do not imply guaranteed performance limits. For guaranteed performance limits and associated test conditions, see the Electrical Characteristics tables.

Note 2: Unless otherwise specified all limits guaranteed for V_{IN} = (V_{ONOM} + 1)V, I_L = 100 µA and C_L = 1 µF for 5V versions and 2.2 µF for 3V and 3.3V versions. Limits appearing in **boldface** type apply over the entire junction temperature range for operation. Limits appearing in normal type apply for $T_A = T_J$ = 25˚C. Additional conditions for the 8-pin versions are FEEDBACK tied to V_{TAP}, OUTPUT tied to SENSE, and $V_{SHUTDOWN}$ ≤ 0.8V.

Note 3: Guaranteed and 100% production tested.

Note 4: Guaranteed but not 100% production tested. These limits are not used to calculate outgoing AQL levels.

Note 5: Dropout Voltage is defined as the input to output differential at which the output voltage drops 100 mV 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.

Note 6: Comparator thresholds are expressed in terms of a voltage differential at the Feedback terminal below the nominal reference voltage measured at V_{in} = (V_ONOM + 1)V. 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 95 mV x 5V/1.235V = 384 mV. 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.

Note 7: $V_{ref} \leq V_{out} \leq (V_{in} - 1V)$, 2.3V ≤ V_{in} ≤ 30V, 100 µA ≤ I_L ≤ 100 mA, $T_J \leq T_{JMAX}$.

Note 8: The junction-to-ambient thermal resistances are as follows: 180˚C/W and 160˚C/W for the TO-92 package with 0.40 inch and 0.25 inch leads to the printed circuit board (PCB) respectively, 105˚C/W for the molded plastic DIP (N), 130˚C/W for the ceramic DIP (J), 160˚C/W for the molded plastic SOP (M), 200˚C/W for the molded plastic MSOP (MM), 160˚C/W for the metal can package (H), and 180˚C/W for the leadless chip carrier (E). The above thermal resistances for the N, J, M, MM, and E packages apply when the package is soldered directly to the PCB. Junction-to-case thermal resistances for the E and H packages are 24˚C/W and 20˚C/W respectively.

Note 9: May exceed input supply voltage.

Note 10: When used in dual-supply systems where the output terminal sees loads returned to a negative supply, the output voltage should be diode-clamped to ground.

Note 11: $V_{shutdown}$ ≥ 2V, V_{in} ≤ 30V, V_{out} = 0, Feedback pin tied to V_{TAP}.

Note 12: Output or reference voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.

Note 13: Thermal regulation is defined as the change in output voltage at a time T after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for a 50 mA load pulse at V_{IN} = 30V (1.25W pulse) for T = 10 ms.

Note 14: 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.

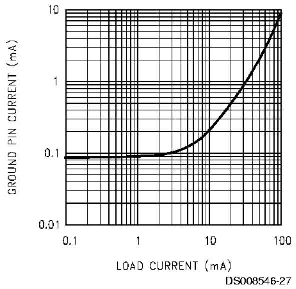
Note 15: Line regulation for the LP2951 is tested at 150˚C for I_L = 1 mA. For I_L = 100 µA and T_J = 125˚C, line regulation is guaranteed by design to 0.2%. See Typical Performance Characteristics for line regulation versus temperature and load current.

Note 16: A Military RETS spec is available on request. At time of printing, the LP2951 RETS spec complied with the boldface limits in this column. The LP2951H, E, or J may also be procured as Standard Military Drawing Spec #5962-3870501MGA, M2A, or MPA.

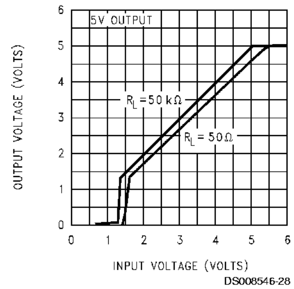
Note 17: All LP2950 devices have the nominal output voltage coded as the last two digits of the part number. In the LP2951 products, the 3.0V and 3.3V versions are designated by the last two digits, but the 5V version is denoted with no code at this location of the part number (refer to ordering information table).

Typical Performance Characteristics

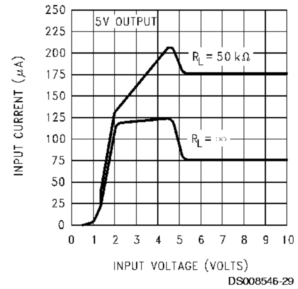
Quiescent Current



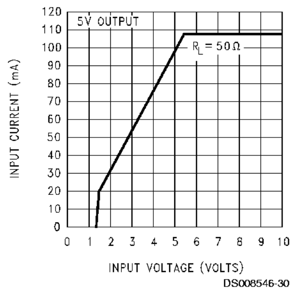
Dropout Characteristics



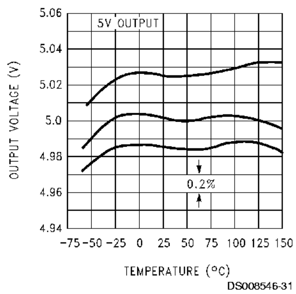
Input Current



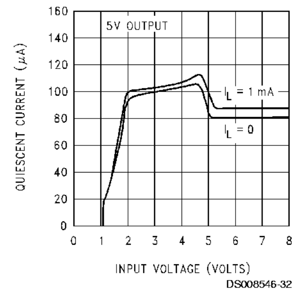
Input Current



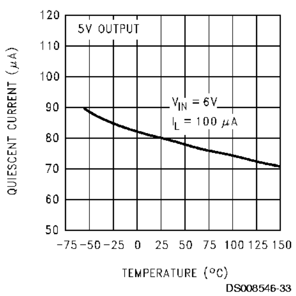
Output Voltage vs. Temperature of 3 Representative Units



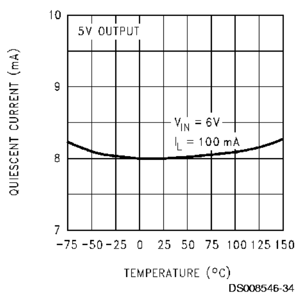
Quiescent Current



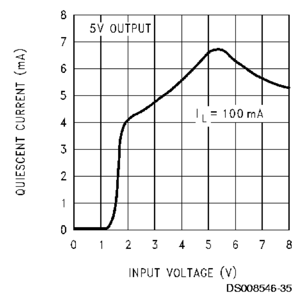
Quiescent Current



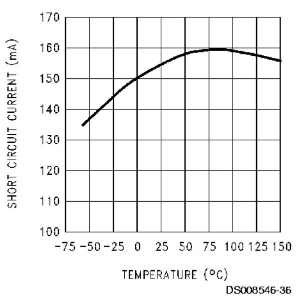
Quiescent Current



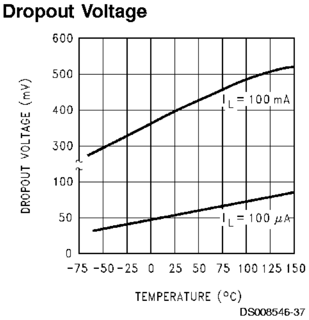
Quiescent Current



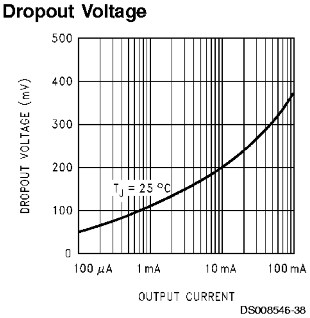
Short Circuit Current



Dropout Voltage

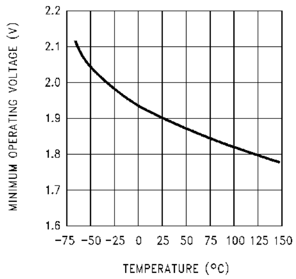


Dropout Voltage



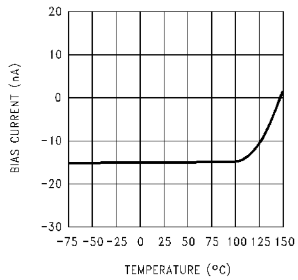
Typical Performance Characteristics (Continued)

LP2951
Minimum Operating Voltage



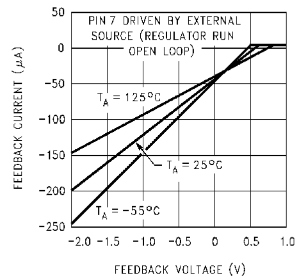
DS008546-39

LP2951
Feedback Bias Current



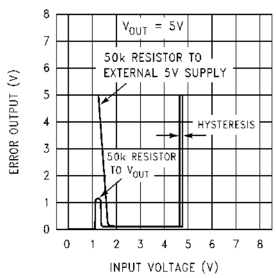
DS008546-40

LP2951
Feedback Pin Current



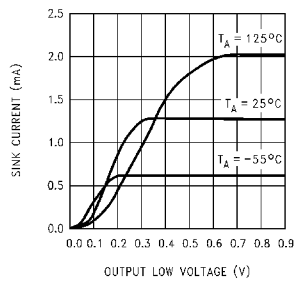
DS008546-41

LP2951
Error Comparator Output



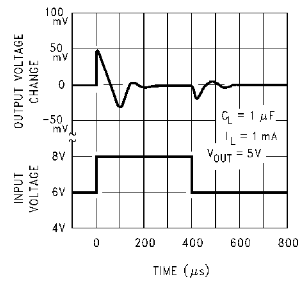
DS008546-42

LP2951
Comparator Sink Current



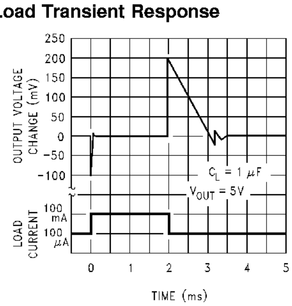
DS008546-43

Line Transient Response



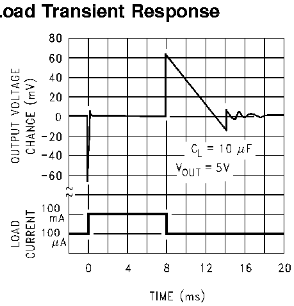
DS008546-44

Load Transient Response



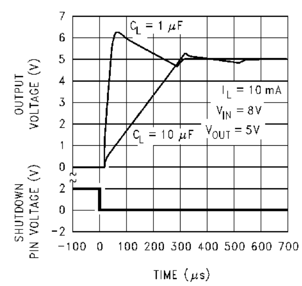
DS008546-45

Load Transient Response



DS008546-46

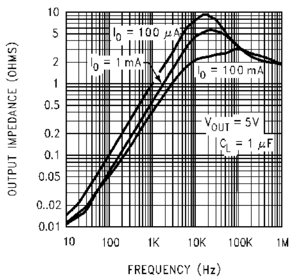
LP2951
Enable Transient



DS008546-47

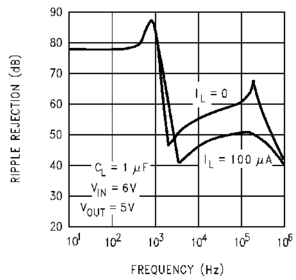
Typical Performance Characteristics (Continued)

Output Impedance



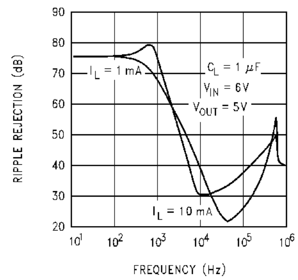
DS008546-48

Ripple Rejection



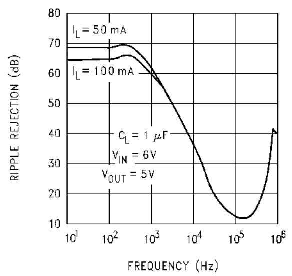
DS008546-49

Ripple Rejection



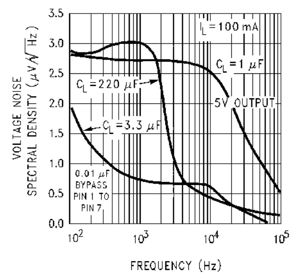
DS008546-50

Ripple Rejection



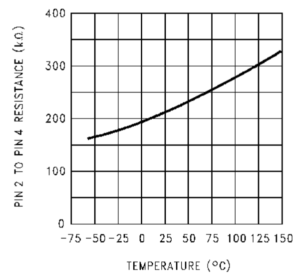
DS008546-51

LP2951 Output Noise



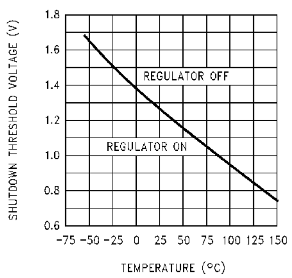
DS008546-52

LP2951 Divider Resistance



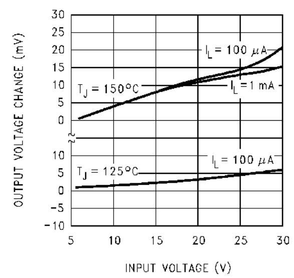
DS008546-53

Shutdown Threshold Voltage



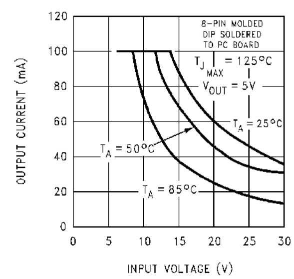
DS008546-54

Line Regulation



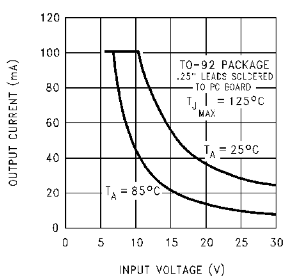
DS008546-55

LP2951 Maximum Rated Output Current



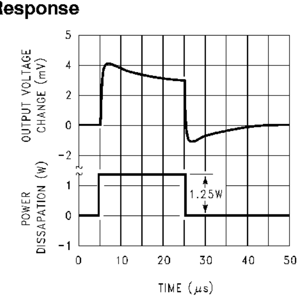
DS008546-56

LP2950 Maximum Rated Output Current



DS008546-57

Thermal Response



DS008546-58

Application Hints

EXTERNAL CAPACITORS

A 1.0 µF (or greater) capacitor is required between the output and ground for stability at output voltages of 5V or more. At lower output voltages, more capacitance is required (2.2 µF or more is recommended for 3V and 3.3V versions). Without this capacitor the part will oscillate. Most types of tantalum or aluminum electrolytics work fine here; even film types work but are not recommended for reasons of cost. Many aluminum electrolytics have electrolytes that freeze at about −30˚C, so solid tantalums are recommended for operation below −25˚C. The important parameters of the capacitor are an ESR of about 5 Ω or less and a resonant frequency above 500 kHz. The value of this capacitor may be increased without limit.

At lower values of output current, less output capacitance is required for stability. The capacitor can be reduced to 0.33 µF for currents below 10 mA or 0.1 µF for currents below 1 mA. Using the adjustable versions at voltages below 5V runs the error amplifier at lower gains so that *more* output capacitance is needed. For the worst-case situation of a 100 mA load at 1.23V output (Output shorted to Feedback) a 3.3 µF (or greater) capacitor should be used.

Unlike many other regulators, the LP2950 will remain stable and in regulation with no load in addition to the internal voltage divider. This is especially important in CMOS RAM keep-alive applications. When setting the output voltage of the LP2951 versions with external resistors, a minimum load of 1 µA is recommended.

A 1 µF tantalum or aluminum electrolytic capacitor should be placed from the LP2950/LP2951 input to ground 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.

Stray capacitance to the LP2951 Feedback terminal can cause instability. This may especially be a problem when using high value external resistors to set the output voltage. Adding a 100 pF capacitor between Output and Feedback and increasing the output capacitor to at least 3.3 µF will fix this problem.

ERROR DETECTION COMPARATOR OUTPUT

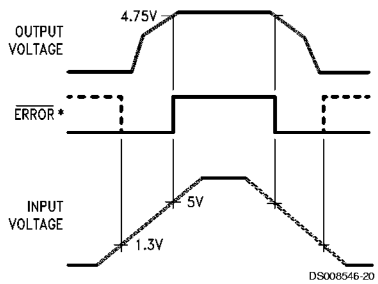
The comparator produces a logic low output whenever the LP2951 output falls out of regulation by more than approximately 5%. This figure is the comparator's built-in offset of about 60 mV divided by the 1.235 reference voltage. (Refer to the block diagram in the front of the datasheet.) This trip level remains "5% below normal" regardless of the programmed output voltage of the 2951. For example, the error flag trip level is typically 4.75V for a 5V output or 11.4V for a 12V output. The out of regulation condition may be due either to low input voltage, current limiting, or thermal limiting.

Figure 1 below gives a timing diagram depicting the $\overline{\text{ERROR}}$ signal and the regulated output voltage as the LP2951 input is ramped up and down. For 5V versions, the $\overline{\text{ERROR}}$ signal becomes valid (low) at about 1.3V input. It goes high at about 5V input (the input voltage at which V_{OUT} = 4.75). Since the LP2951's dropout voltage is load-dependent (see curve in typical performance characteristics), the **input** voltage trip point (about 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 pullup resistor. This resistor may be returned to the output or some other supply voltage depending on system requirements. In determining a value for this resistor, note that while the output is rated to sink 400 µA, this sink current adds to battery drain in a low battery condition. Suggested values range from 100k to 1 MΩ. The resistor is not required if this output is unused.

PROGRAMMING THE OUTPUT VOLTAGE (LP2951)

The LP2951 may be pin-strapped for the nominal fixed output voltage using its internal voltage divider by tying the output and sense pins together, and also tying the feedback and V_{TAP} pins together. Alternatively, it may be programmed for any output voltage between its 1.235V reference and its 30V maximum rating. As seen in *Figure 2*, an external pair of resistors is required.



*When V_{IN} ≤ 1.3V, the error flag pin becomes a high impedance, and the error flag voltage rises to its pull-up voltage. Using V_{OUT} as the pull-up voltage (see *Figure 2*), rather than an external 5V source, will keep the error flag voltage under 1.2V (typ.) in this condition. The user may wish to divide down the error flag voltage using equal-value resistors (10 kΩ suggested), to ensure a low-level logic signal during any fault condition, while still allowing a valid high logic level during normal operation.

FIGURE 1. $\overline{\text{ERROR}}$ Output Timing

The complete equation for the output voltage is

$$V_{OUT} = V_{REF} \bullet \left(1 + \frac{R_1}{R_2}\right) + I_{FB}R_1$$

where V_{REF} is the nominal 1.235 reference voltage and I_{FB} is the feedback pin bias current, nominally −20 nA. The minimum recommended load current of 1 µA forces an upper limit of 1.2 MΩ on the value of R_2, if the regulator must work with no load (a condition often found in CMOS in standby). I_{FB} will produce a 2% typical error in V_{OUT} which may be eliminated at room temperature by trimming R_1. For better accuracy, choosing R_2 = 100k reduces this error to 0.17% while increasing the resistor program current to 12 µA. Since the LP2951 typically draws 60 µA at no load with Pin 2 open-circuited, this is a small price to pay.

Application Hints (Continued)

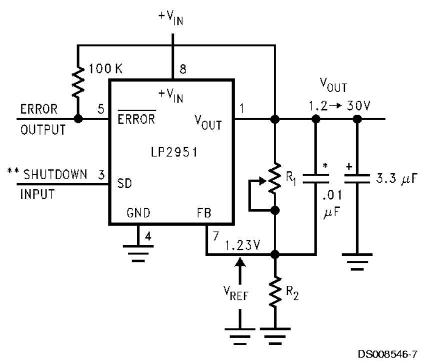
REDUCING OUTPUT NOISE

In reference applications it may be advantageous to reduce the AC noise present at the output. One method is to reduce the regulator bandwidth by increasing the size of the output capacitor. This is the only way noise can be reduced on the 3 lead LP2950 but is relatively inefficient, as increasing the capacitor from 1 µF to 220 µF only decreases the noise from 430 µV to 160 µV rms for a 100 kHz bandwidth at 5V output.

Noise can be reduced fourfold by a bypass capacitor across R_1, since it reduces the high frequency gain from 4 to unity. Pick

$$C_{BYPASS} \cong \frac{1}{2\pi R_1 \bullet 200\ \text{Hz}}$$

or about 0.01 µF. When doing this, the output capacitor must be increased to 3.3 µF to maintain stability. These changes reduce the output noise from 430 µV to 100 µV rms for a 100 kHz 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.



*See Application Hints

$$V_{out} = V_{Ref}\left(1 + \frac{R_1}{R_2}\right)$$

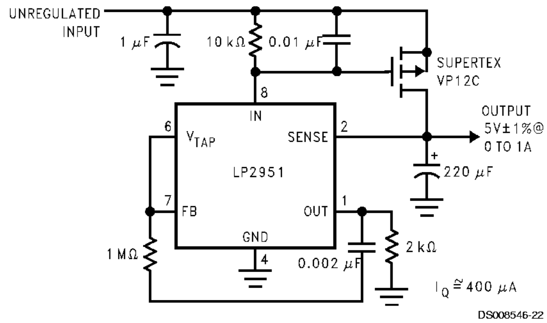
**Drive with TTL-high to shut down. Ground or leave open if shutdown feature is not to be used.

Note: Pins 2 and 6 are left open.

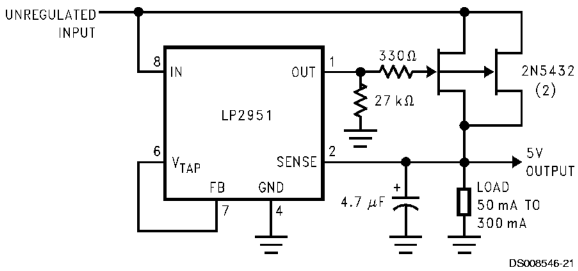
FIGURE 2. Adjustable Regulator

Typical Applications

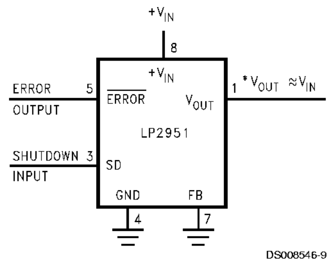
1A Regulator with 1.2V Dropout



300 mA Regulator with 0.75V Dropout

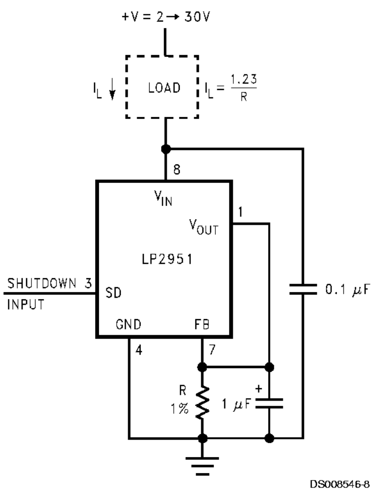


Wide Input Voltage Range Current Limiter

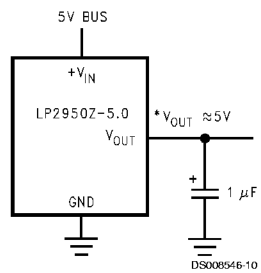


*Minimum input-output voltage ranges from 40 mV to 400 mV, depending on load current. Current limit is typically 160 mA.

Low Drift Current Source



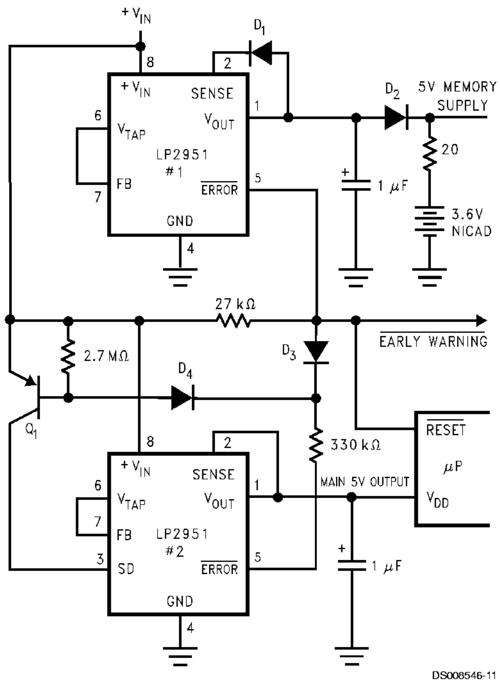
5 Volt Current Limiter



*Minimum input-output voltage ranges from 40 mV to 400 mV, depending on load current. Current limit is typically 160 mA.

Typical Applications (Continued)

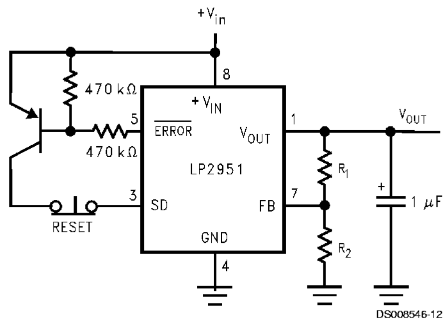
Regulator with Early Warning and Auxiliary Output



- Early warning flag on low input voltage
- Main output latches off at lower input voltages
- Battery backup on auxiliary output

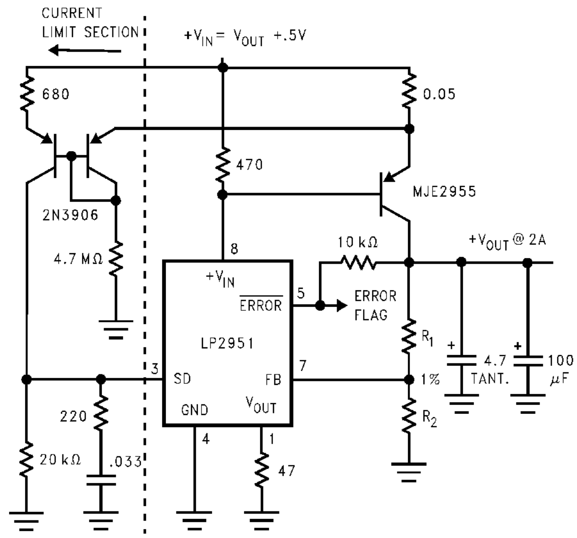
Operation: Reg. #1's V_{out} is programmed one diode drop above 5V. Its error flag becomes active when $V_{in} \leq 5.7V$. When V_{in} drops below 5.3V, the error flag of Reg. #2 becomes active and via Q1 latches the main output off. When V_{in} again exceeds 5.7V Reg. #1 is back in regulation and the early warning signal rises, unlatching Reg. #2 via D3.

Latch Off When Error Flag Occurs



Typical Applications (Continued)

2 Ampere Low Dropout Regulator

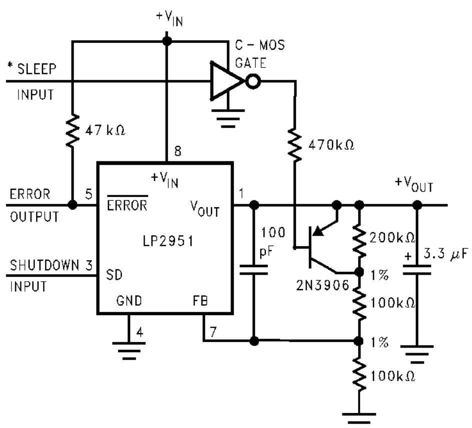


DS008546-13

$$V_{out} = 1.23V\left(1 + \frac{R_1}{R_2}\right)$$

For $5V_{out}$, use internal resistors. Wire pin 6 to 7, & wire pin 2 to $+V_{out}$ Buss.

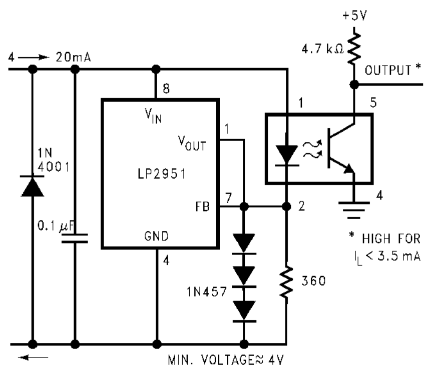
5V Regulator with 2.5V Sleep Function



DS008546-14

*High input lowers V_{out} to 2.5V

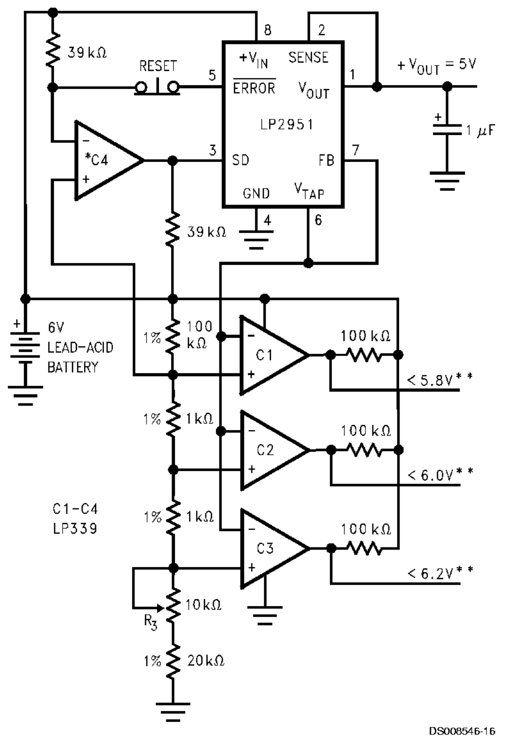
Open Circuit Detector for 4 → 20 mA Current Loop



DS008546-15

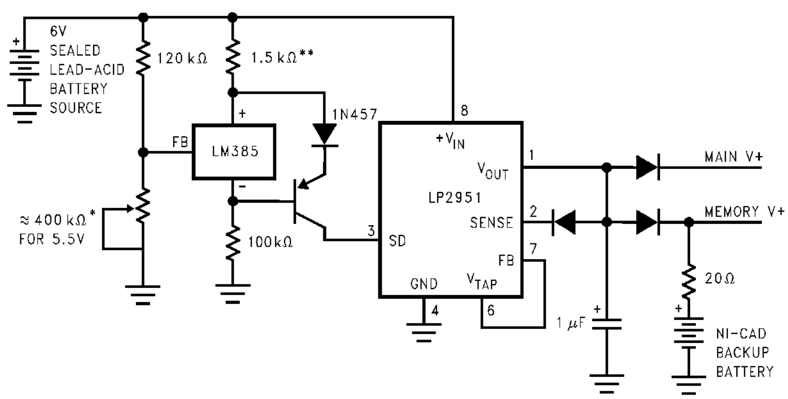
Typical Applications (Continued)

Regulator with State-of-Charge Indicator



*Optional Latch off when drop out occurs. Adjust R3 for C2 Switching when V_{in} is 6.0V.
**Outputs go low when V_{in} drops below designated thresholds.

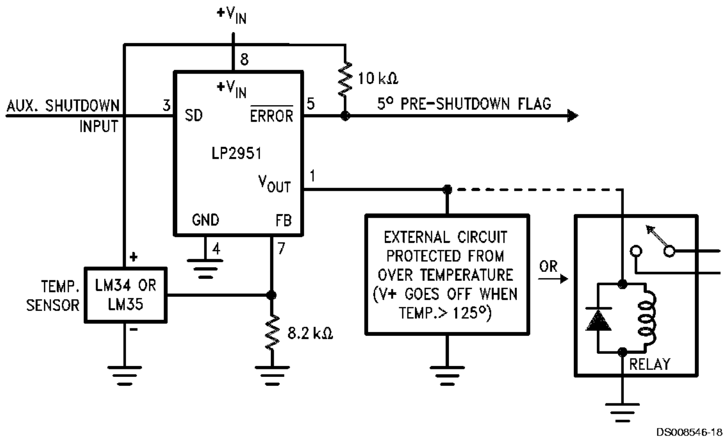
Low Battery Disconnect



For values shown, Regulator shuts down when V_{in} < 5.5V and turns on again at 6.0V. Current drain in disconnected mode is ≈ 150 µA.
*Sets disconnect Voltage
**Sets disconnect Hysteresis

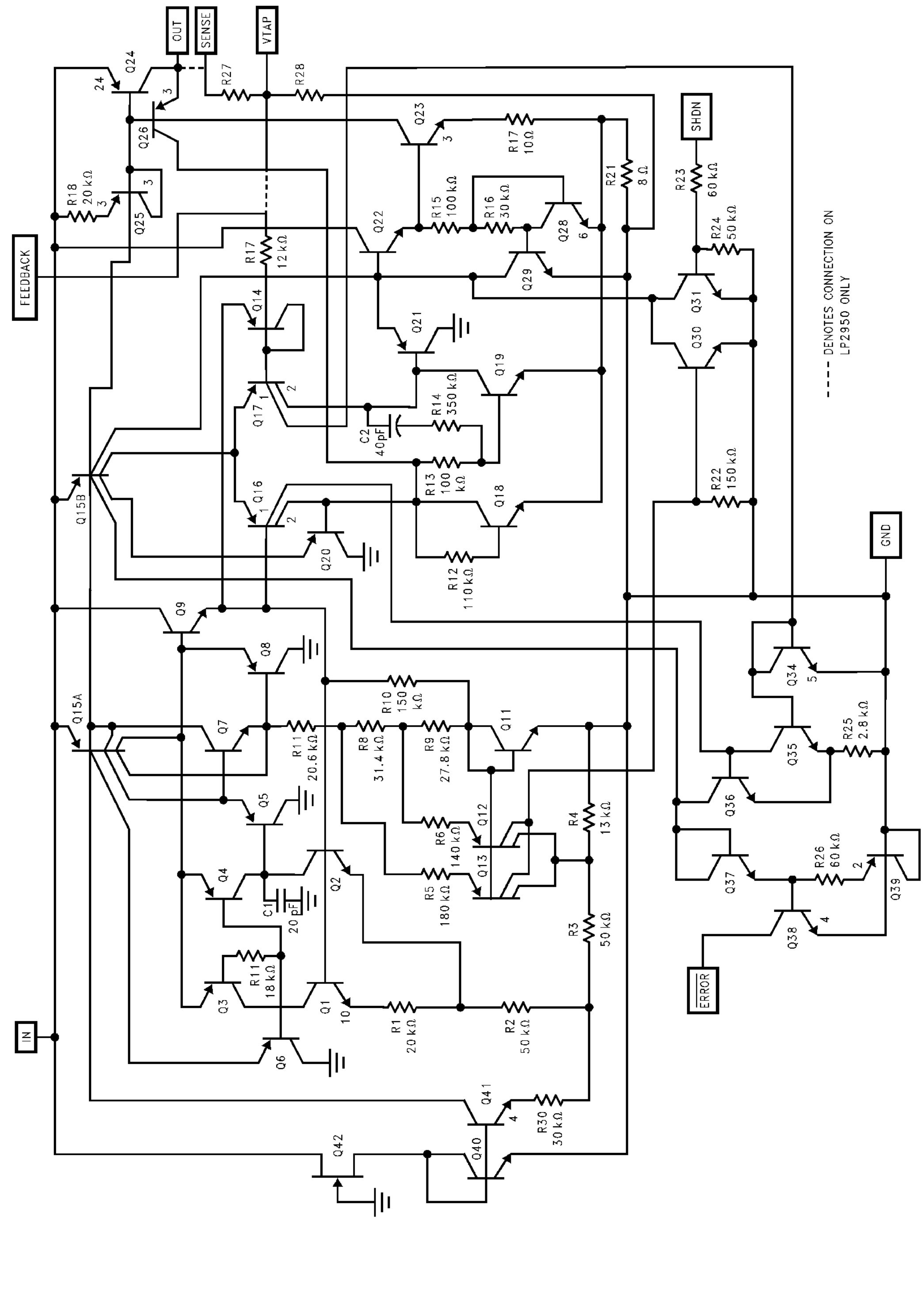
Typical Applications (Continued)

System Overtemperature Protection Circuit



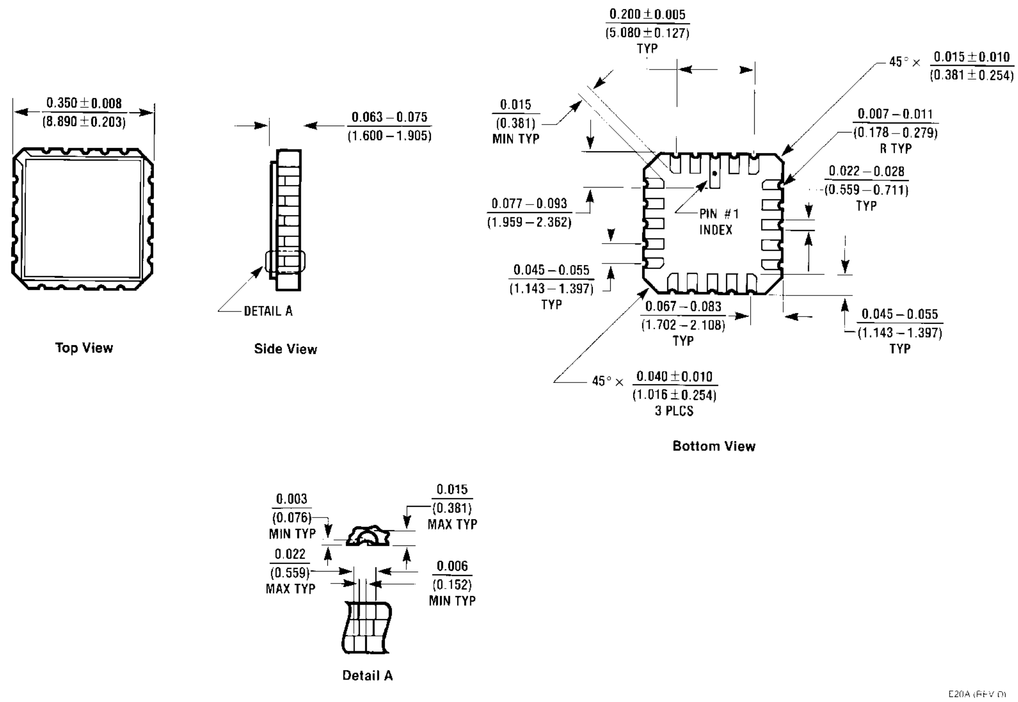
LM34 for 125˚F Shutdown
LM35 for 125˚C Shutdown

Schematic Diagram

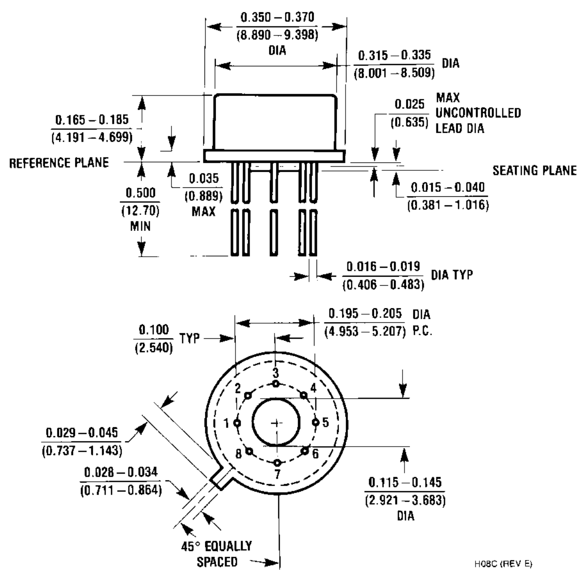


DS008546-23

Physical Dimensions inches (millimeters) unless otherwise noted

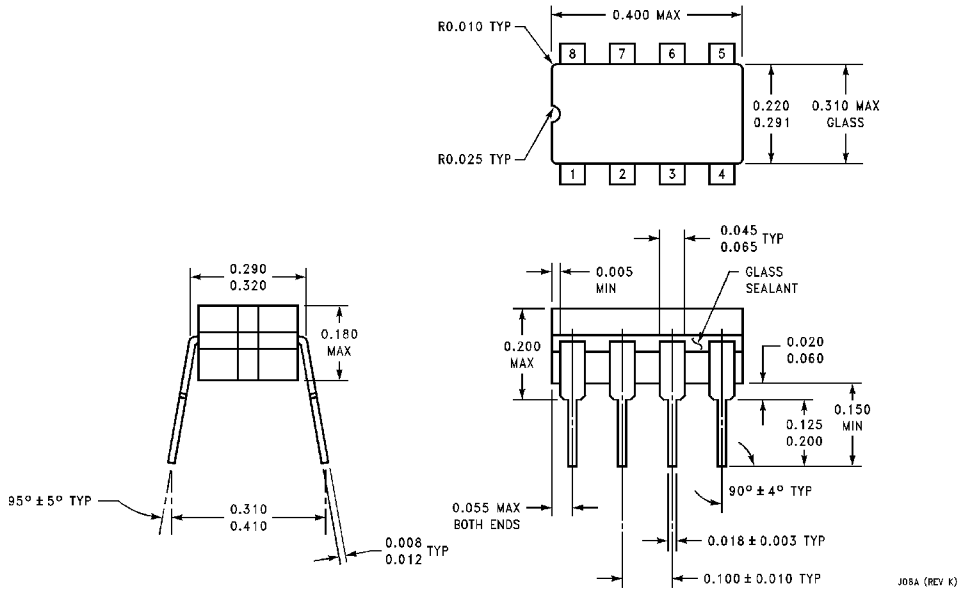


Order Number LP2951E/883 or 5962-3870501M2A
NS Package Number E20A

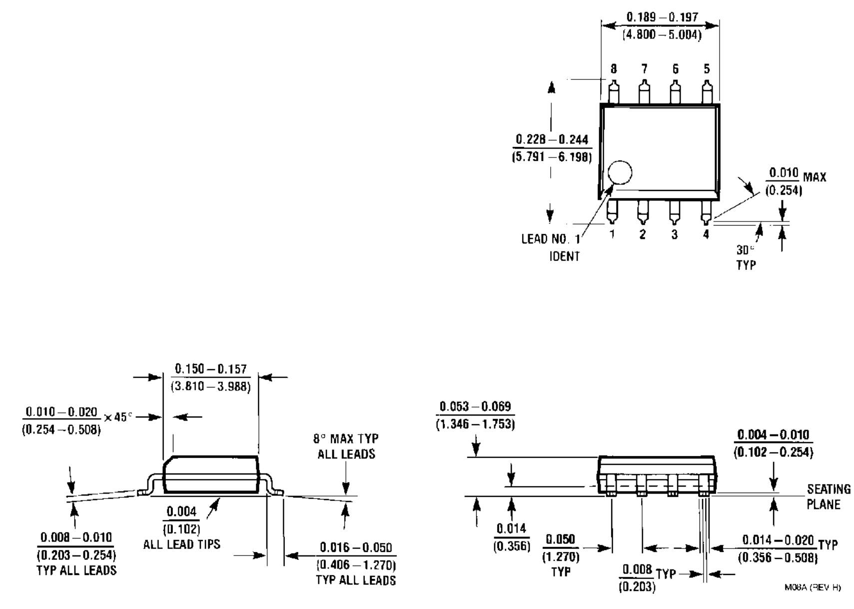


Metal Can Package (H)
Order Number LP2951H/883 or 5962-3870501MGA
NS Package Number H08C

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

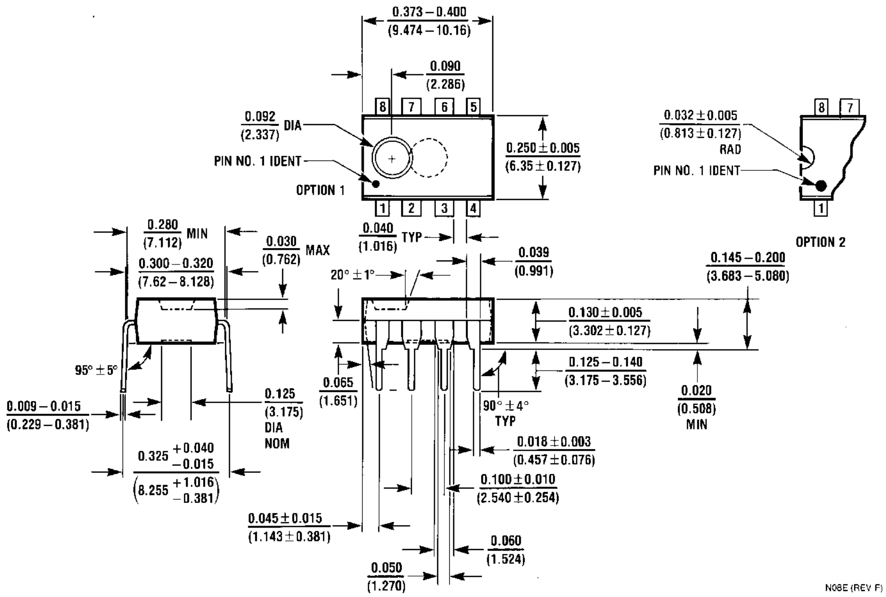


Ceramic Dual-In-Line Package (J)
Order Number LP2951CJ, LP2951ACJ, LP2951J, LP2951J/883 or 5962-3870501MPA
NS Package Number J08A

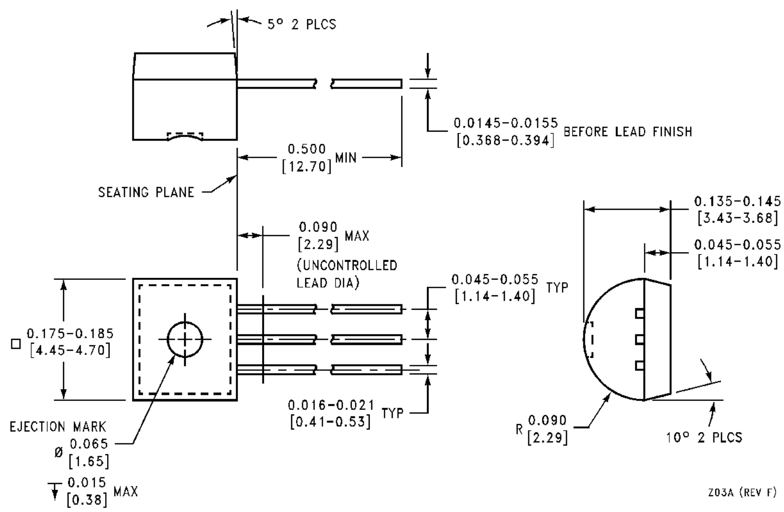


Surface Mount Package (M)
Order Number LP2951ACM, LP2951CM, LP2951ACM-3.0,
LP2951CM-3.0, LP2951ACM-3.3 or LP2951CM-3.3
NS Package Number M08A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

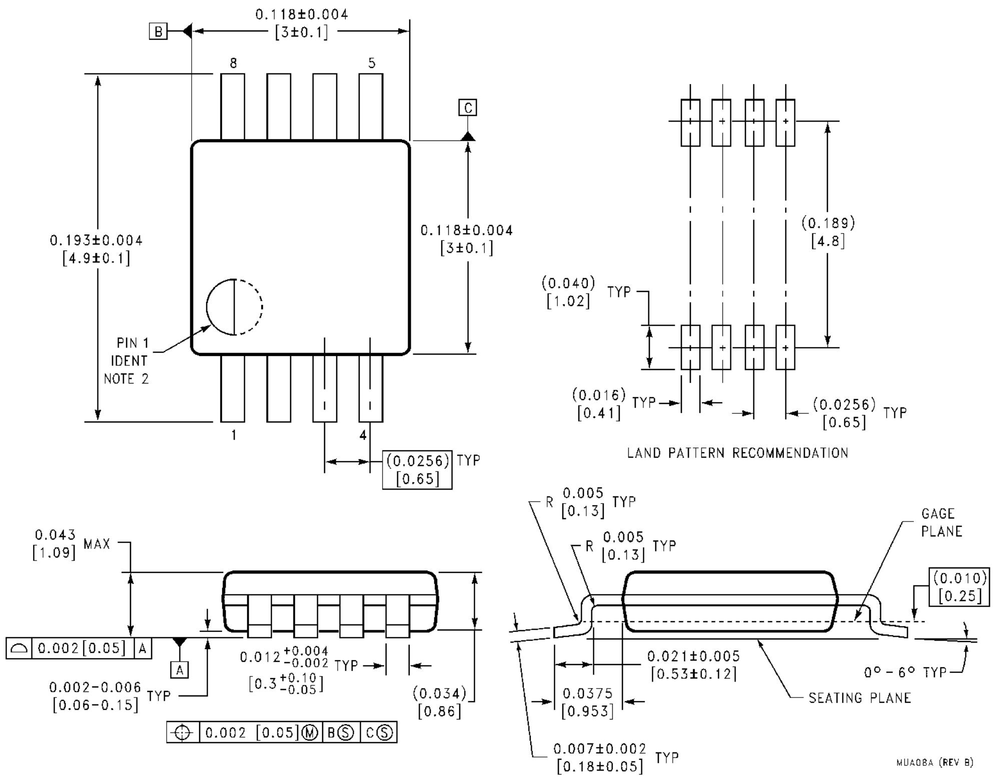


Molded Dual-In-Line Package (N)
Order Number LP2951ACN, LP2951CN, LP2951ACN-3.0,
LP2951CN-3.0, or LP2951ACN-3.3 or LP2951CN-3.3
NS Package Number N08E



Molded TO-92 Package (Z)
Order Number LP2950ACZ-3.0 or LP2950CZ-3.0, LP2950ACZ-3.3,
LP2950CZ-3.3, LP2950ACZ-5.0 or LP2950CZ-5.0
NS Package Number Z03A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



Surface Mount Package (MM)
Order Number LP2951ACMM, LP2951CMM, LP2951ACMM-3.0,
LP2951CMM-3.0, LP2951ACMM-3.3 or LP2951CMM-3.3
NS Package Number MUA08A

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

National Semiconductor Corporation
Americas
Tel: 1-800-272-9959
Fax: 1-800-737-7018
Email: support@nsc.com

www.national.com

National Semiconductor Europe
Fax: +49 (0) 1 80-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 1 80-530 85 85
English Tel: +49 (0) 1 80-532 78 32
Français Tel: +49 (0) 1 80-532 93 58
Italiano Tel: +49 (0) 1 80-534 16 80

National Semiconductor Asia Pacific Customer Response Group
Tel: 65-2544466
Fax: 65-2504466
Email: sea.support@nsc.com

National Semiconductor Japan Ltd.
Tel: 81-3-5620-6175
Fax: 81-3-5620-6179