

LP2950/LP2951

Series of Adjustable Micropower Voltage Regulators

General Description

The LP2950 and LP2951 are micropower voltage regulators with very low quiescent current (75µA typ.) and very low dropout voltage (typ. 40mV at light loads and 380mV at 100mA). 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 is available in the surface-mount D-Pak package, and in the popular 3-pin TO-92 package for pin-compatibility with older 5V regulators. The 8-lead LP2951 is available in plastic, ceramic dual-in-line, LLP, 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.

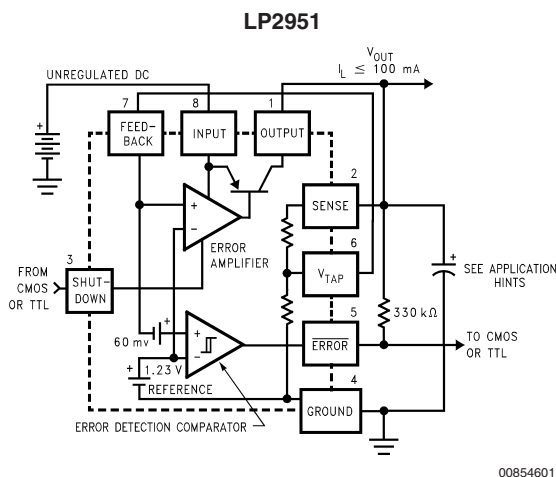
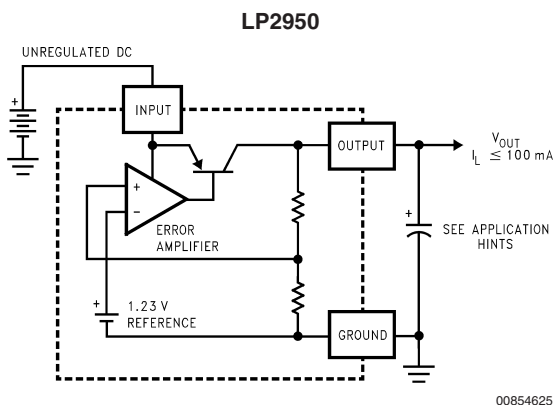
Features

- 5V, 3V, and 3.3V versions available
- High accuracy output voltage
- Guaranteed 100mA 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
- Stable with low-ESR output capacitors (10mΩ to 6Ω)

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



Ordering Information

Package	Temperature Range	Part Number	Package Marking	Transport Media	NSC Drawing
TO-92 (Z)	$-40 < T_J < 125$	LP2950ACZ-3.0	2950A CZ3.0	Bag	Z03A
		LP2950CZ-3.0	2950 CZ3.0	Bag	
		LP2950ACZ-3.3	2950A CZ3.3	Bag	
		LP2950CZ-3.3	2950 CZ3.3	Bag	
		LP2950ACZ-5.0	2950A CZ5.0	Bag	
		LP2950CZ-5.0	2950 CZ5.0	Bag	
TO-252 (D-Pak)	$-40 < T_J < 125$	LP2950CDT-3.0	LP2950CDT-3.0	75 Units/Rail	TD03B
		LP2950CDTX-3.0		2.5k Units Tape and Reel	
		LP2950CDT-3.3	LP2950CDT-3.3	75 Units/Rail	
		LP2950CDTX-3.3		2.5k Units Tape and Reel	
		LP2950CDT-5.0	LP2950CDT-5.0	75 Units/Rail	
		LP2950CDTX-5.0		2.5k Units Tape and Reel	
N (N-08E)	$-40 < T_J < 125$	LP2951ACN-3.0	LP2951ACN-3.0	40 Units/Rail	N08E
		LP2951CN-3.0	LP2951CN-3.0	40 Units/Rail	
		LP2951ACN-3.3	LP2951ACN-3.3	40 Units/Rail	
		LP2951CN-3.3	LP2951CN-3.3	40 Units/Rail	
		LP2951ACN	LP2951ACN	40 Units/Rail	
		LP2951CN	LP2951CN	40 Units/Rail	
M (M08A)	$-40 < T_J < 125$	LP2951ACM-3.0	2951ACM30* (where * is die rev letter)	95 Units/Rail	M08A
		LP2951ACMX-3.0		2.5k Units Tape and Reel	
		LP2951CM-3.0	2951CM30* (where * is die rev letter)	95 Units/Rail	
		LP2951CMX-3.0		2.5k Units Tape and Reel	
		LP2951ACM-3.3	2951ACM33* (where * is die rev letter)	95 Units/Rail	
		LP2951ACMX-3.3		2.5k Units Tape and Reel	
		LP2951CM-3.3	2951CM33* (where * is die rev letter)	95 Units/Rail	
		LP2951CMX-3.3		2.5k Units Tape and Reel	
		LP2951ACM	2951ACM* (where * is die rev letter)	95 Units/Rail	
		LP2951ACMX		2.5k Units Tape and Reel	
		LP2951CM	2951CM* (where * is die rev letter)	95 Units/Rail	
		LP2951CMX		2.5k Units Tape and Reel	
MM (MUA08A)	$-40 < T_J < 125$	LP2951ACMM-3.0	L0BA	1k Units Tape and Reel	MUA08A
		LP2951ACMMX-3.0		3.5k Units Tape and Reel	
		LP2951CMM-3.0	L0BB	1k Units Tape and Reel	
		LP2951CMMX-3.0		3.5k Units Tape and Reel	
		LP2951ACMM-3.3	L0CA	1k Units Tape and Reel	
		LP2951ACMMX-3.3		3.5k Units Tape and Reel	
		LP2951CMM-3.3	L0CB	1k Units Tape and Reel	
		LP2951CMMX-3.3		3.5k Units Tape and Reel	
		LP2951ACMM	L0DA	1k Units Tape and Reel	
		LP2951ACMMX		3.5k Units Tape and Reel	
		LP2951CMM	L0DB	1k Units Tape and Reel	
		LP2951CMMX		3.5k Units Tape and Reel	
J (J08A)	$-55 < T_J < 150$	LP2951J/883	See MIL/AERO Datasheet	40 Units/Rail	J08A
H (H08C)	$-55 < T_J < 150$	LP2951H/883	See MIL/AERO Datasheet	Tray	H08C
WG (WG10A)	$-55 < T_J < 150$	LP2951WG/883	See MIL/AERO Datasheet	Tray	WG10A

Ordering Information (Continued)

Package	Temperature Range	Part Number	Package Marking	Transport Media	NSC Drawing
8-lead LLP	$-40 < T_J < 125$	LP2951ACSD-3.0	51AC30	1k Units Tape and Reel	SDC08A
		LP2951ACSDX-3.0		4.5k Units Tape and Reel	
		LP2951CSD-3.0	51AC30B	1k Units Tape and Reel	
		LP2951CSDX-3.0		4.5k Units Tape and Reel	
		LP2951ACSD-3.3	51AC33	1k Units Tape and Reel	
		LP2951ACSDX-3.3		4.5k Units Tape and Reel	
		LP2951CSD-3.3	51AC33B	1k Units Tape and Reel	
		LP2951CSDX-3.3		4.5k Units Tape and Reel	
		LP2951ACSD	2951AC	1k Units Tape and Reel	
		LP2951ACSDX		4.5k Units Tape and Reel	
		LP2951CSD	2951ACB	1k Units Tape and Reel	
		LP2951CSDX		4.5k Units Tape and Reel	

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 Rating

Human Body Model(Note 18)

2500V

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 2.985	3.0	3.015 2.985		3.0	3.030 2.970		V max V min
	−25°C ≤ T _J ≤ 85°C	3.0		3.0		3.030 2.970	3.0		3.045 2.955	V max V min
	Full Operating Temperature Range	3.0	3.036 2.964	3.0		3.036 2.964	3.0		3.060 2.940	V max V min
Output Voltage	100μA ≤ I _L ≤ 100mA	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 3.284	3.3	3.317 3.284		3.3	3.333 3.267		V max V min
	−25°C ≤ T _J ≤ 85°C	3.3		3.3		3.333 3.267	3.3		3.350 3.251	V max V min
	Full Operating Temperature Range	3.3	3.340 3.260	3.3		3.340 3.260	3.3		3.366 3.234	V max V min
Output Voltage	100μA ≤ I _L ≤ 100mA	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 4.975	5.0	5.025 4.975		5.0	5.05 4.95		V max V min
	−25°C ≤ T _J ≤ 85°C	5.0		5.0		5.05 4.95	5.0		5.075 4.925	V max V min
	Full Operating	5.0	5.06	5.0		5.06	5.0		5.1	V 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)	
	Temperature Range		4.94			4.94			4.9	V min
Output Voltage	$100\mu\text{A} \leq I_L \leq 100\text{mA}$	5.0	5.075	5.0		5.075	5.0		5.12	V max
	$T_J \leq T_{J\text{MAX}}$		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)	$(V_{\text{ONOM}} + 1)\text{V} \leq V_{\text{in}} \leq 30\text{V}$ (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)	$100\mu\text{A} \leq I_L \leq 100\text{mA}$	0.04	0.1	0.04	0.1		0.1	0.2		% max
			0.3			0.2			0.3	% max
Dropout Voltage (Note 5)	$I_L = 100\mu\text{A}$	50	80	50	80		50	80		mV max
			150			150			150	mV max
	$I_L = 100\text{mA}$	380	450	380	450	600	380	450	600	mV max
Ground Current	$I_L = 100\mu\text{A}$	75	120	75	120		75	120		μA max
			140			140			140	μA max
	$I_L = 100\text{mA}$	8	12	8	12	14	8	12	14	mA max
Dropout	$V_{\text{in}} = (V_{\text{ONOM}} - 0.5)\text{V}$	110	170	110	170		110	170		μA max
Ground Current	$I_L = 100\mu\text{A}$		200			200			200	μA max
Current Limit	$V_{\text{out}} = 0$	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, 10 Hz to 100 kHz	$C_L = 1\mu\text{F}$ (5V Only)	430		430			430			μV rms
	$C_L = 200\mu\text{F}$	160		160			160			μV rms
	$C_L = 3.3\mu\text{F}$ (Bypass = $0.01\mu\text{F}$ Pins 7 to 1 (LP2951))	100		100			100			μV rms
8-pin Versions Only		LP2951		LP2951AC-XX			LP2951C-XX			
Reference Voltage		1.235	1.25	1.235	1.25		1.235	1.26		V max
			1.26			1.26			1.27	V max
			1.22							V min
			1.2			1.2			1.2	V min
Reference Voltage	(Note 7)		1.27			1.27			1.285	V max
			1.19			1.19			1.185	V min
Feedback Pin Bias Current		20	40	20	40	60	20	40	60	nA max
Reference Voltage	(Note 12)	20		20			50			ppm/°C

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										
Temperature Coefficient										
Feedback Pin Bias Current Temperature Coefficient		0.1		0.1			0.1			nA/°C
Error Comparator										
Output Leakage Current	V _{OH} = 30V	0.01	1 2	0.01	1	2	0.01	1	2	µA max µA max
Output Low Voltage	V _{in} = (V _{ONOM} – 0.5)V	150	250	150	250		150	250		mV max
Voltage	I _{OL} = 400µA		400			400			400	mV max
Upper Threshold Voltage	(Note 6)	60	40 25	60	40	25	60	40	25	mV min mV min
Lower Threshold Voltage	(Note 6)	75	95 140	75	95	140	75	95	140	mV max mV max
Hysteresis	(Note 6)	15		15			15			mV
Shutdown Input										
Input Logic Voltage	Low (Regulator ON) High (Regulator OFF)	1.3	0.6 2.0	1.3		0.7 2.0	1.3		0.7 2.0	V V max V min
Shutdown Pin Input Current	V _{shutdown} = 2.4V	30	50 100	30	50	100	30	50	100	µA max µA max
	V _{shutdown} = 30V	450	600 750	450	600	750	450	600	750	µA max µA max
Regulator Output Current in Shutdown	(Note 11)	3	10 20	3	10	20	3	10	20	µA max 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 $V_{IN} = (V_{ONOM} + 1)V$, $I_L = 100\mu A$ and $C_L = 1\mu F$ for 5V versions and $2.2\mu F$ 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 $T_A = T_J = 25^\circ C$. Additional conditions for the 8-pin versions are FEEDBACK tied to V_{TAP} , OUTPUT tied to SENSE, and $V_{SHUTDOWN} \leq 0.8V$.

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 $95mV \times 5V/1.235V = 384 mV$. 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: $V_{ref} \leq V_{out} \leq (V_{in} - 1V)$, $2.3V \leq V_{in} \leq 30V$, $100\mu A \leq I_L \leq 100mA$, $T_J \leq T_{JMAX}$.

Note 8: The junction-to-ambient thermal resistances are as follows: $180^\circ C/W$ and $160^\circ C/W$ for the TO-92 package with 0.40 inch and 0.25 inch leads to the printed circuit board (PCB) respectively, $105^\circ C/W$ for the molded plastic DIP (N), $130^\circ C/W$ for the ceramic DIP (J), $160^\circ C/W$ for the molded plastic SOP (M), $200^\circ C/W$ for the molded plastic MSOP (MM), and $160^\circ C/W$ for the metal can package (H). The above thermal resistances for the N, J, M, and MM packages apply when the package is soldered directly to the PCB. Junction-to-case thermal resistance for the H package is $20^\circ C/W$. Junction-to-case thermal resistance for the TO-252 package is $5.4^\circ C/W$. The value of θ_{JA} for the LLP package is typically $51^\circ C/W$ but is dependent on the PCB trace area, trace material, and the number of layers and thermal vias. For details of thermal resistance and power dissipation for the LLP package, refer to Application Note AN-1187.

Note 9: May exceed input supply voltage.

Electrical Characteristics (Note 2) (Continued)

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: $V_{\text{shutdown}} \geq 2\text{V}$, $V_{\text{in}} \leq 30\text{V}$, $V_{\text{out}} = 0$, 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 50mA load pulse at $V_{\text{IN}} = 30\text{V}$ (1.25W pulse) for $T = 10\text{ms}$.

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 $I_L = 1\text{mA}$. For $I_L = 100\mu\text{A}$ and $T_J = 125^\circ\text{C}$, 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 specification is available on request. At time of printing, the LP2951 RETS specification complied with the boldface limits in this column. The LP2951H, WG, or J may also be procured as Standard Military Drawing Spec #5962-3870501MGA, MXA, 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).

Note 18: Human Body Model $1.5\text{k}\Omega$ in series with 100pF .