National Semiconductor

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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

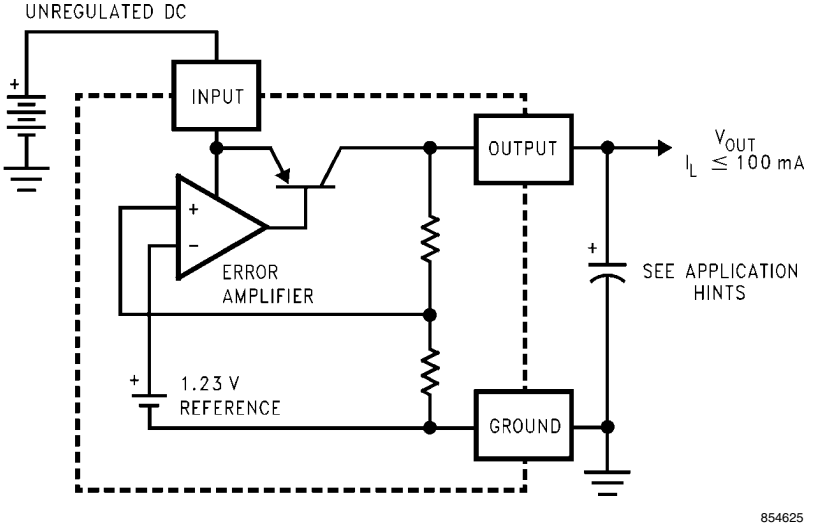
- 5V, 3V, and 3.3V versions available
- High accuracy output voltage
- Guaranteed 100mA output current
- Extremely low quiescent current
- Low dropout voltage
- Extremely tight load and line regulation
- Very low temperature coefficient
- Use as Regulator or Reference
- Needs minimum capacitance for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

LP2950



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*)	
LP2950AC-XX, LP2950C-XX	−40° to +125°C
LP2951	−55° to +150°C
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 (*Note 3*) (*Note 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 Temperature Range	3.0	**3.036**	3.0		**3.036**	3.0		**3.060**	V max
			2.964			**2.964**			**2.940**	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	3.3	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 Temperature Range	3.3	**3.340**	3.3		**3.340**	3.3		**3.366**	V max
			3.260			**3.260**			**3.234**	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	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 Temperature Range	5.0	**5.06**	5.0		**5.06**	5.0		**5.1**	V max
			4.94			**4.94**			**4.9**	V min
Output Voltage	100µA ≤ I_L ≤ 100mA	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

Parameter	Conditions (*Note 2*)	LP2951		LP2950AC-XX LP2951AC-XX			LP2950C-XX LP2951C-XX			Units
		Typ	Tested Limit (*Note 3*) (*Note 16*)	Typ	Tested Limit (*Note 3*)	Design Limit (*Note 4*)	Typ	Tested Limit (*Note 3*)	Design Limit (*Note 4*)	
All Voltage Options										
Output Voltage Temperature Coefficient	(*Note 12*)	**20**	**120**	**20**		**100**	**50**		**150**	ppm/°C
Line Regulation (*Note 14*)	$(V_O NOM + 1)V \le V_{in} \le 30V$ (*Note 15*)	0.03	0.1 **0.5**	0.03	0.1	 **0.2**	0.04	0.2 	 **0.4**	% max % max
Load Regulation (*Note 14*)	$100\mu A \le I_L \le 100mA$	0.04	0.1 **0.3**	0.04	0.1	 **0.2**	0.1	0.2 	 **0.3**	% max % max
Dropout Voltage (*Note 5*)	I_L = 100µA	 50	80 **150**	 50	80	 **150**	 50	80 	 **150**	mV max mV max
	I_L = 100mA	 380	450 **600**	 380	450	 **600**	 380	450 	 **600**	mV max mV max
Ground Current	I_L = 100µA	75	120 **140**	75	120	 **140**	75	120 	 **140**	µA max µA max
	I_L = 100mA	8	12 **14**	8	12	 **14**	8	12 	 **14**	mA max mA max
Dropout Ground Current	$V_{in} = (V_O NOM - 0.5)$ V I_L = 100µA	110	170 **200**	110	170	 **200**	110	170 	 **200**	µA max µA max
Current Limit	V_{out} = 0	160	200 **220**	160	200	 **220**	160	200 	 **220**	mA max 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 = 1µF (5V Only)	430		430			430			µV rms
	C_L = 200µF	160		160			160			µV rms
	C_L = 3.3µF (Bypass = 0.01µF 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 **1.26** 1.22 **1.2**	1.235	1.25 1.22 	 **1.26** **1.2**	1.235	1.26 1.21 	 **1.27** **1.2**	V max V max V min V min
Reference Voltage	(*Note 7*)		**1.27** **1.19**			**1.27** **1.19**			**1.285** **1.185**	V max V min
Feedback Pin Bias Current		20	40 **60**	20	40	 **60**	20	40 	 **60**	nA max 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

Parameter	Conditions (*Note 2*)	LP2951		LP2950AC-XX LP2951AC-XX			LP2950C-XX LP2951C-XX			Units
		Typ	Tested Limit (*Note 3*) (*Note 16*)	Typ	Tested Limit (*Note 3*)	Design Limit (*Note 4*)	Typ	Tested Limit (*Note 3*)	Design Limit (*Note 4*)	
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 I_{OL} = 400µA	150	250 **400**	150	250	 **400**	150	250	 **400**	mV max 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 = 100µA and C_L = 1µF for 5V versions and 2.2µF 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 $V_{SHUTDOWN} \leq$ 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 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 $\leq V_{in} \leq$ 30V, 100µA $\leq I_L \leq$ 100mA, $T_J \leq T_{JMAX}$.

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), and 160°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°C/W. Junction-to-case thermal resistance for the TO-252 package is 5.4°C/W. The value of θ_{JA} for the LLP package is typically 51°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.

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

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 = 1mA. For I_L = 100µA 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.