National Semiconductor

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

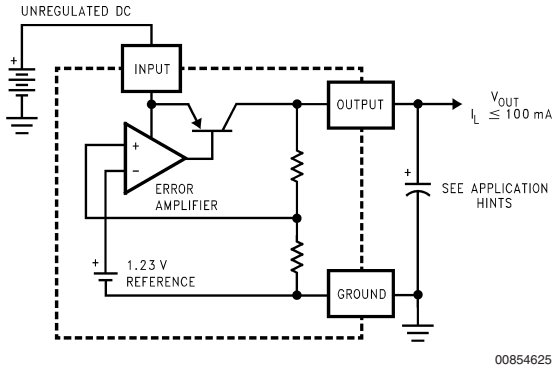
- 5V, 3V, and 3.3V versions available
- High accuracy output voltage
- Guaranteed 100mA output current
- Extremely low quiescent current
- Low dropout voltage
- Extremely tight load and line regulation
- Very low temperature coefficient
- Use as Regulator or Reference
- Needs minimum capacitance for stability
- Current and Thermal Limiting
- Stable with low-ESR output capacitors (10mΩ to 6Ω)

LP2951 versions only

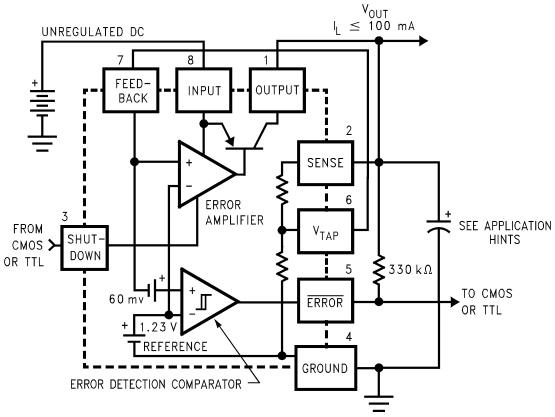
- Error flag warns of output dropout
- Logic-controlled electronic shutdown
- Output programmable from 1.24 to 29V

Block Diagram and Typical Applications

LP2950



LP2951



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

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 T_J ≤ T_{JMAX}	3.0	**3.045** **2.955**	3.0		**3.042** **2.958**	3.0		**3.072** **2.928**	V max 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 T_J ≤ T_{JMAX}	3.3	**3.350** **3.251**	3.3		**3.346** **3.254**	3.3		**3.379** **3.221**	V max 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	100µA ≤ I_L ≤ 100mA	5.0	**5.075**	5.0		**5.075**	5.0		**5.12**	V max
	$T_J \le T_{JMAX}$		**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)	100µA ≤ I_L ≤ 100mA	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 = 100µA		80		80			80		mV max
		50	**150**	50		**150**	50		**150**	mV max
	I_L = 100mA		450		450			450		mV max
		380	**600**	380		**600**	380		**600**	mV max
Ground Current	I_L = 100µA	75	120	75	120		75	120		µA max
			140			**140**			**140**	µA max
	I_L = 100mA	8	12	8	12		8	12		mA max
			14			**14**			**14**	mA max
Dropout Ground Current	V_{in} = (V_ONOM – 0.5)V	110	170	110	170		110	170		µA max
	I_L = 100µA		**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, 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	1.235	1.25		1.235	1.26		V max
			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 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		20	40		nA max
			60			**60**			**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 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.

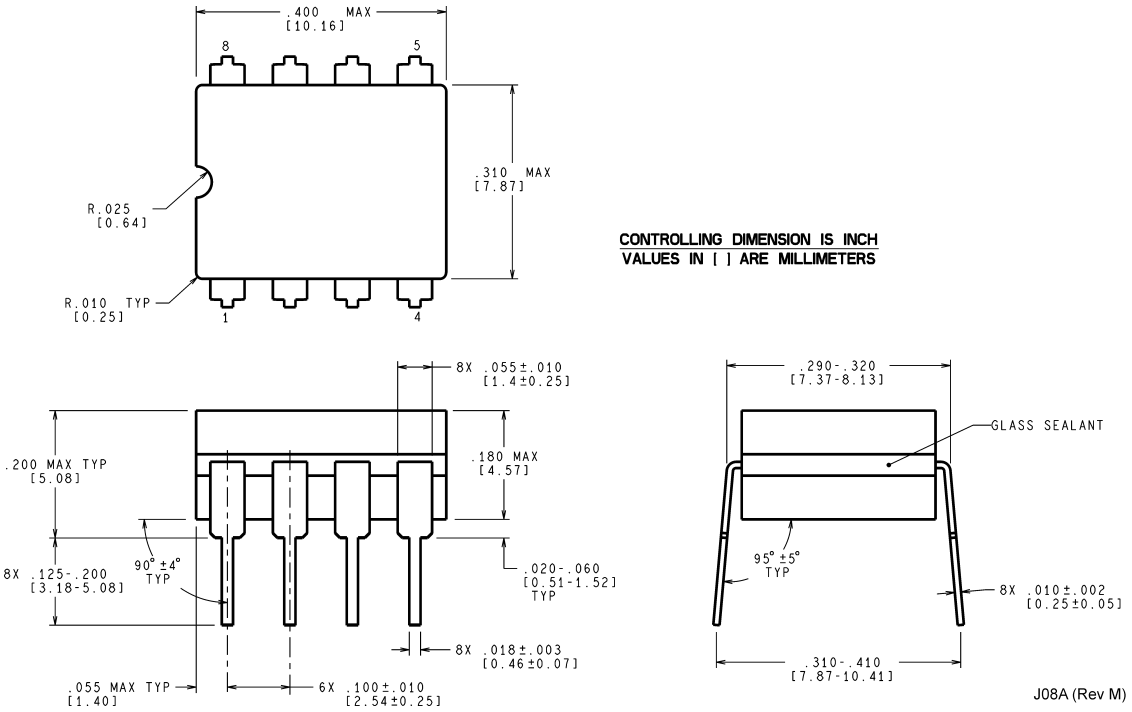
Note 6: Comparator thresholds are expressed in terms of a voltage differential at the Feedback terminal below the nominal reference voltage measured at V_{in} = (V_ONOM + 1)V. To express these thresholds in terms of output voltage change, multiply by the error amplifier gain = V_{out}/V_{ref} = (R1 + 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: $V_{ref} \leq V_{out} \leq (V_{in} - 1V)$, $2.3V \leq V_{in} \leq 30V$, $100\mu A \leq I_L \leq 100mA$, $T_J \leq T_{JMAX}$.

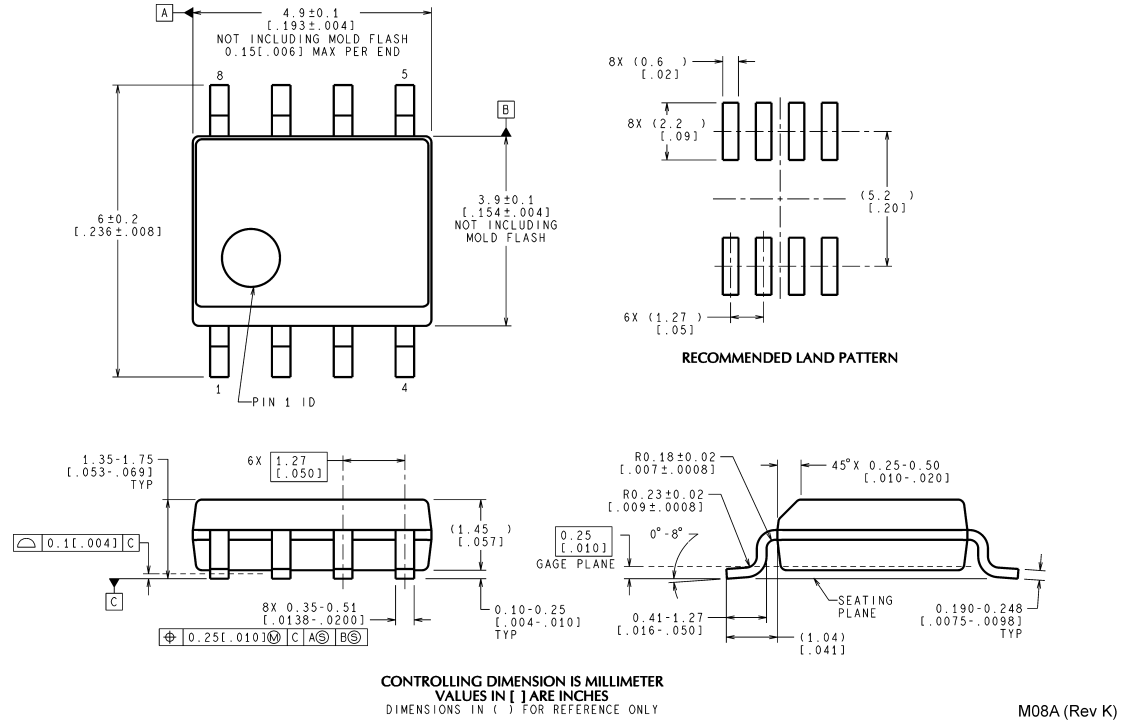
Note 8: The junction-to-ambient thermal resistances are as follows: 180˚C/W and 160˚C/W for the TO-92 package with 0.40 inch and 0.25 inch leads to the printed circuit board (PCB) respectively, 105˚C/W for the molded plastic DIP (N), 130˚C/W for the ceramic DIP (J), 160˚C/W for the molded plastic SOP (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.

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

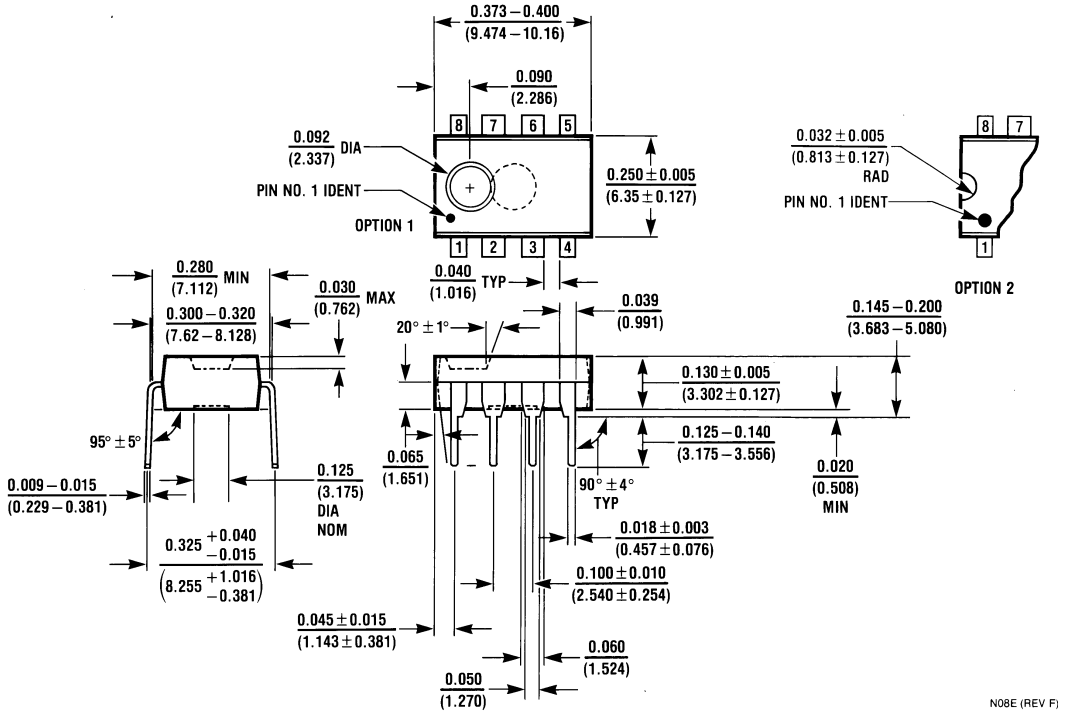


Ceramic Dual-In-Line Package (J)
NS Package Number J08A

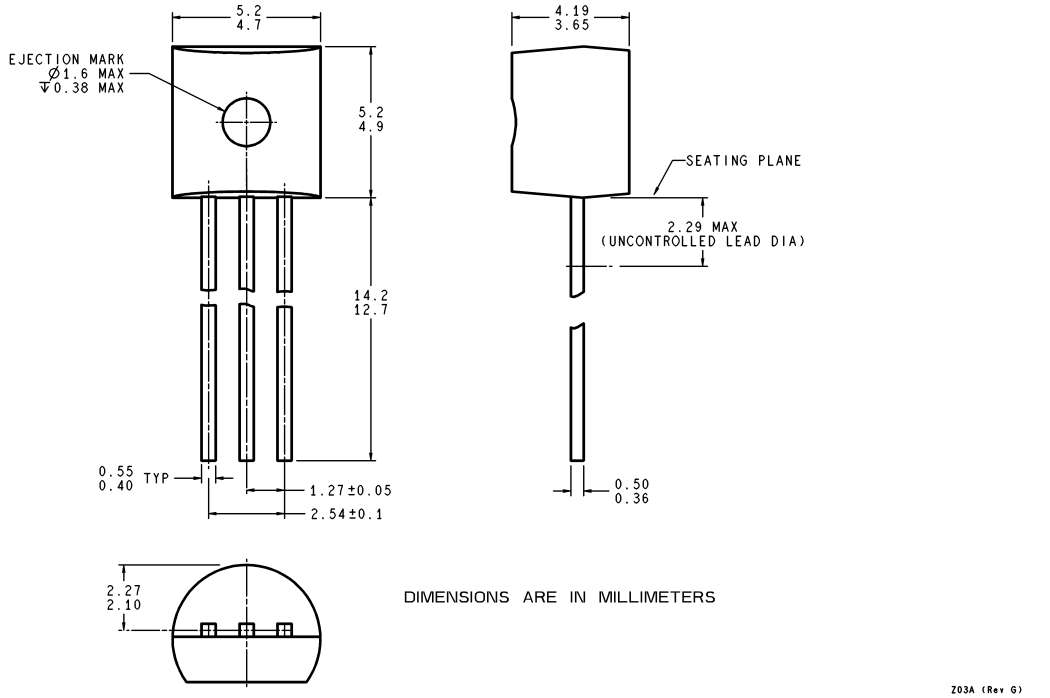


Surface Mount Package (M)
NS Package Number M08A

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



Molded Dual-In-Line Package (N)
NS Package Number N08E



Molded TO-92 Package (Z)
NS Package Number Z03A