

**XL285-2.5 SOP8/XL385-2.5 SOP8/XB385M3-2.5 SOT23/XT385-2.5 T092/XT285-2.5 T092**

**FEATURES**

- $\pm 20$  mV ( $\pm 0.8\%$ ) max. Initial Tolerance (A Grade)
- Operating Current of 20  $\mu$ A to 20 mA
- 0.6 $\Omega$  Dynamic Impedance (A Grade)
- Low Temperature Coefficient
- Low Voltage Reference—2.5V
- 1.2V Device and Adjustable Device Also Available— 285-2.5 Series and 285 Series, respectively

**DESCRIPTION**

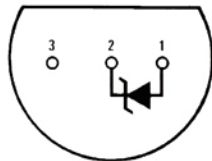
The 285-2.5/385-2.5 are micropower 2-terminal band-gap voltage regulator diodes. Operating over a 20  $\mu$ A to 20 mA current range, they feature exceptionally low dynamic impedance and good temperature stability. On-chip trimming is used to provide tight voltage tolerance. Since the 285-2.5 band-gap reference uses only transistors and resistors, low noise and good long term stability result.

Careful design of the 285-2.5 has made the device exceptionally tolerant of capacitive loading, making it easy to use in almost any reference application. The wide dynamic operating range allows its use with widely varying supplies with excellent regulation.

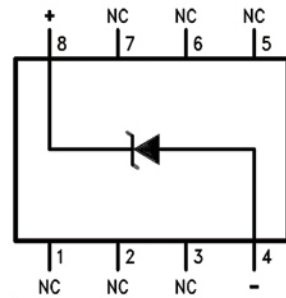
The extremely low power drain of the 285-2.5 makes it useful for micropower circuitry. This voltage reference can be used to make portable meters, regulators or general purpose analog circuitry with battery life approaching shelf life. Further, the wide operating current allows it to replace older references with a tighter tolerance part. For applications requiring 1.2V see 285-2.5.

The 285-2.5 is rated for operation over a  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  temperature range while the 285-2.5 is rated  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  and the 285-2.5  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The 285-2.5/385-2.5 are available in a hermetic TO package and the 285-2.5/385-2.5 are also available in a low-cost TO-92 molded package, as well as SOIC and SOT-23. The 285-2.5 is also available in a hermetic leadless chip carrier package.

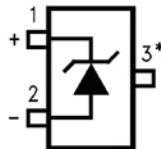
**Connection Diagram**



**Figure 1. TO-92 Package (Bottom View)**  
 See Package Number LP0003A

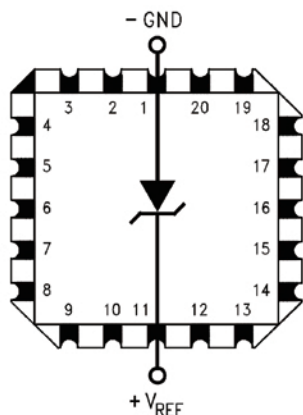


**Figure 2. SOIC Package**  
 See Package Number D0008A

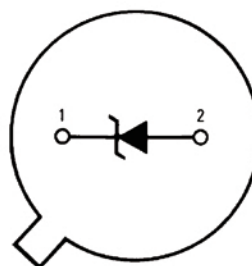


\* Pin 3 is attached to the Die Attach Pad (DAP) and should be connected to Pin 2 or left floating.

**Figure 3. SOT-23**



**Figure 4. LCCC Leadless Chip Carrier**  
See Package Number NAJ0020A



**Figure 5. TO Package (Bottom View)**  
See Package Number NDU0002A



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

**ABSOLUTE MAXIMUM RATINGS** <sup>(1)(2)(3)</sup>

Reverse Current		30 mA	
Forward Current		10 mA	
Operating Temperature Range <sup>(4)</sup>	XL185-N	-55°C to + 125°C	
	XL285-N	-40°C to + 85°C	
	XL385-N	0°C to 70°C	
ESD Susceptibility <sup>(5)</sup>		2kV	
Storage Temperature		-55°C to + 150°C	
Soldering Information	TO-92 Package (10 sec.)	260°C	
	TO Package (10 sec.)	300°C	
	SOIC and SOT-23 Package	Vapor Phase (60 sec.)	215°C
		Infrared (15 sec.)	220°C

See <http://www.ti.com> for other methods of soldering surface mount devices.

- (1) Refer to RETS185H-2.5 for military specifications.
- (2) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed.
- (3) If Military/Aerospace specified devices are required, please contact the TI Sales Office/Distributors for availability and specifications.
- (4) For elevated temperature operation, T<sub>J</sub> MAX is:  
 XL185-N : 150°C  
 XL285-N : 125°C  
 XL385-N : 100°C  
 See **THERMAL CHARACTERISTICS**.
- (5) The human body model is a 100 pF capacitor discharged through a 1.5 kΩ resistor into each pin.

**THERMAL CHARACTERISTICS**

over operating free-air temperature range (unless otherwise noted)

Thermal Resistance	XL185	150°C	SOIC-8	SOT-23
	XL285	125°C		
	XL385	100°C		
	TO-92	TO		
θ <sub>ja</sub> (Junction to Ambient)	180°C/W (0.4" Leads)	440°C/W	165°C/W	283°C/W
	170°C/W (0.125" Leads)			
θ <sub>jc</sub> (Junction to Case)	N/A	80°C/W	N/A	N/A

**ELECTRICAL CHARACTERISTICS**

Parameter	Conditions	Typ	XL385-2.5-N		Units (Limits)	
			Tested Limit <sup>(2)</sup>	Design Limit <sup>(3)</sup>		
Reverse Breakdown Voltage	$I_R = 100 \mu\text{A}$	2.500	2.480 2.520		V(Min) V(Max)	
		<b>2.500</b>		<b>2.470</b> <b>2.530</b>	V(Min) V(Max)	
Minimum Operating Current		12	18	<b>20</b>	$\mu\text{A}$ (Max)	
Reverse Breakdown Voltage Change with Current	$I_{\text{MIN}} \leq I_R \leq 1\text{mA}$		1	<b>1.5</b>	mV (Max)	
	$1\text{mA} \leq I_R \leq 20\text{mA}$		10	<b>20</b>	mV (Max)	
Reverse Dynamic Impedance	$I_R = 100 \mu\text{A}$ , $f = 20\text{Hz}$	0.2		0.6	$\Omega$	
				<b>1.5</b>		
Wideband Noise (rms)	$I_R = 100 \mu\text{A}$ $10\text{Hz} \leq f \leq 10\text{kHz}$	120			$\mu\text{V}$	
Long Term Stability	$I_R = 100 \mu\text{A}$ , $T = 1000\text{Hr}$ , $T_A = 25^\circ\text{C} \pm 0.1^\circ\text{C}$	20			ppm	
Average Temperature Coefficient <sup>(4)</sup>	$I_{\text{MIN}} \leq I_R \leq 20\text{mA}$ X Suffix Y Suffix All Others				ppm/ $^\circ\text{C}$ (Max)	
				<b>30</b>		
				<b>50</b>		<b>150</b>

(1) Parameters identified with boldface type apply at temperature extremes. All other numbers apply at  $T_A = T_J = 25^\circ\text{C}$ .

(2) Specified and 100% production tested.

(3) Specified, but not 100% production tested. These limits are not used to calculate average outgoing quality levels.

(4) The average temperature coefficient is defined as the maximum deviation of reference voltage at all measured temperatures between the operating  $T_{\text{MAX}}$  and  $T_{\text{MIN}}$ , divided by  $T_{\text{MAX}} - T_{\text{MIN}}$ . The measured temperatures are  $-55^\circ\text{C}$ ,  $-40^\circ\text{C}$ ,  $0^\circ\text{C}$ ,  $25^\circ\text{C}$ ,  $70^\circ\text{C}$ ,  $85^\circ\text{C}$ ,  $125^\circ\text{C}$ .

**ELECTRICAL CHARACTERISTICS**

Parameter	Conditions	Typ	XL185	XL385				XL385		Units (Limit)
			XL185	XL385				XL385		
			XL185	XL385				XL385		
			XL285	XL385				XL385		
			XL285	XL385				XL385		
			XL285	XL385				XL385		
			Tested Limit <sup>(1)(2)</sup>	Design Limit <sup>(3)</sup>	Tested Limit <sup>(1)</sup>	Design Limit <sup>(3)</sup>	Tested Limit <sup>(1)</sup>	Design Limit <sup>(3)</sup>		
Reverse Breakdown Voltage	$T_A = 25^\circ\text{C}$ , $20\ \mu\text{A} \leq I_R \leq 20\ \text{mA}$	2.5	2.462		2.462		2.425		V(Min)	
			2.538		2.538		2.575		V(Max)	
Minimum Operating Current	XL385	13	20	<b>30</b>	20	<b>30</b>	20	<b>30</b>	$\mu\text{A}$ (Max)	
							15	<b>20</b>		
Reverse Breakdown Voltage Change with Current	$20\ \mu\text{A} \leq I_R \leq 1\ \text{mA}$		1	<b>1.5</b>	2.0	<b>2.5</b>	2.0	<b>2.5</b>	mV (Max)	
	$1\ \text{mA} \leq I_R \leq 20\ \text{mA}$		10	<b>20</b>	20	<b>25</b>	20	<b>25</b>	mV (Max)	
Reverse Dynamic Impedance	$I_R = 100\ \mu\text{A}$ , $f = 20\ \text{Hz}$	1							$\Omega$	
Wideband Noise (rms)	$I_R = 100\ \mu\text{A}$ , $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$	120							$\mu\text{V}$	
Long Term Stability	$I_R = 100\ \mu\text{A}$ , $T = 1000\ \text{Hr}$ , $T_A = 25^\circ\text{C} \pm 0.1^\circ\text{C}$	20							ppm	
Average Temperature Coefficient <sup>(4)</sup>	$I_R = 100\ \mu\text{A}$									
	X Suffix		<b>30</b>		<b>30</b>				ppm/ $^\circ\text{C}$	
	Y Suffix		<b>50</b>		<b>50</b>				ppm/ $^\circ\text{C}$	
All Others			<b>150</b>		<b>150</b>		<b>150</b>	ppm/ $^\circ\text{C}$ (Max)		

- (1) Specified and 100% production tested.
- (2) A military RETS electrical specification available on request.
- (3) Specified, but not 100% production tested. These limits are not used to calculate average outgoing quality levels.
- (4) The average temperature coefficient is defined as the maximum deviation of reference voltage at all measured temperatures between the operating  $T_{MAX}$  and  $T_{MIN}$ , divided by  $T_{MAX}-T_{MIN}$ . The measured temperatures are  $-55^\circ\text{C}$ ,  $-40^\circ\text{C}$ ,  $0^\circ\text{C}$ ,  $25^\circ\text{C}$ ,  $70^\circ\text{C}$ ,  $85^\circ\text{C}$ ,  $125^\circ\text{C}$ .

TYPICAL PERFORMANCE CHARACTERISTICS

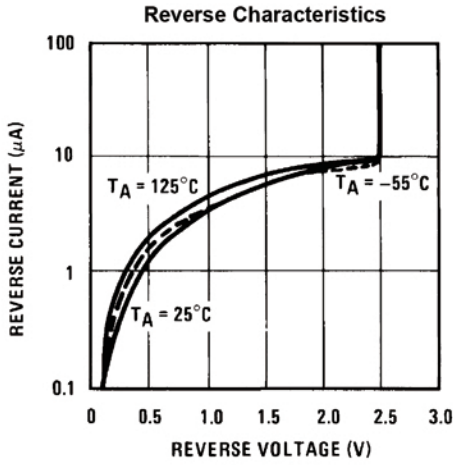


Figure 6.

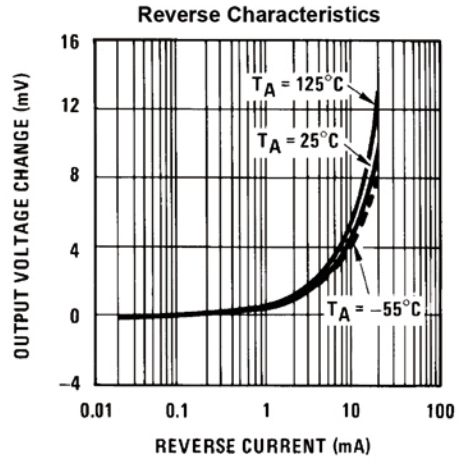


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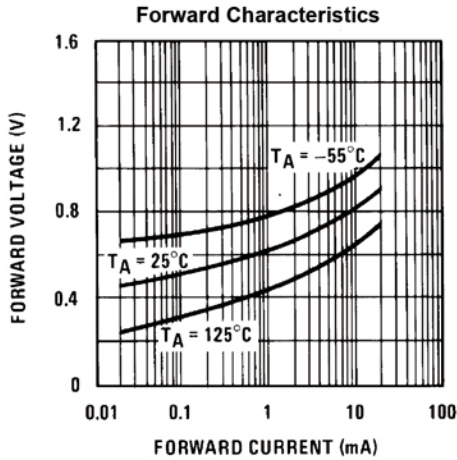


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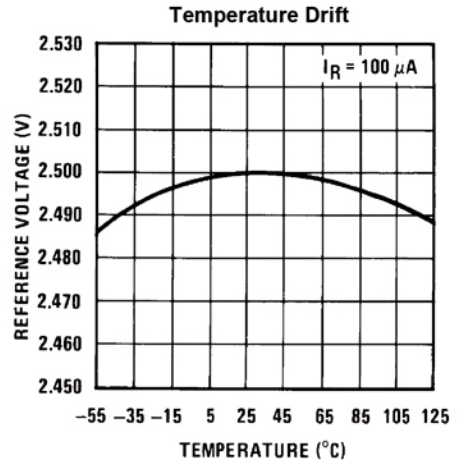


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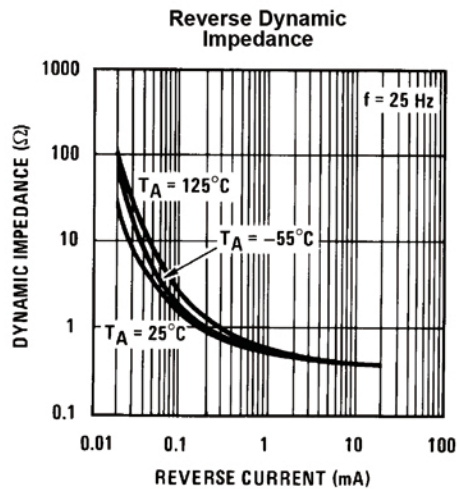


Figure 10.

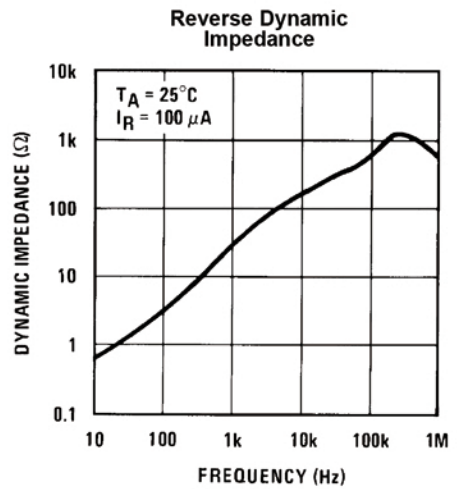
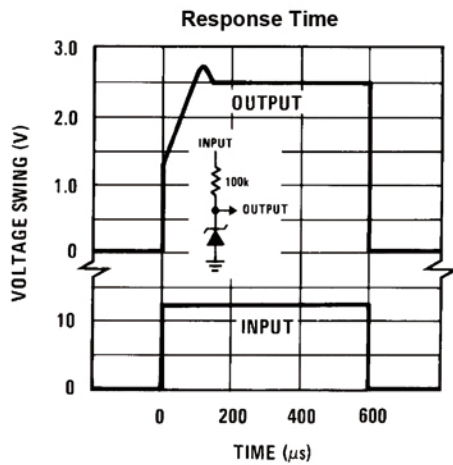
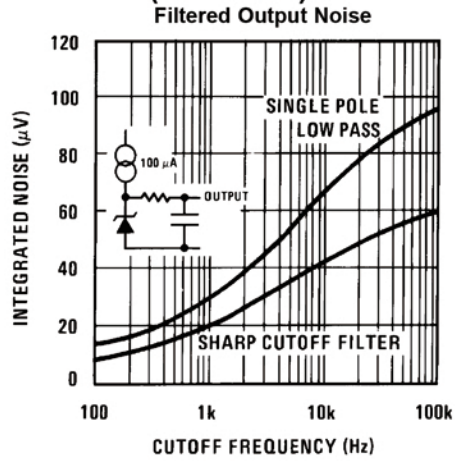
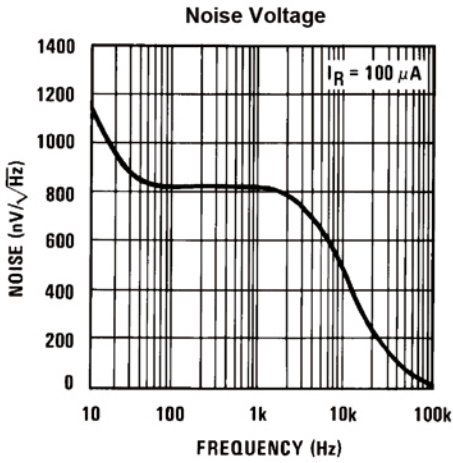
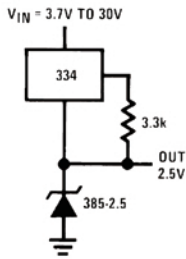


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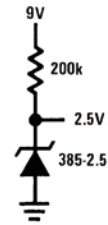
**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**



**APPLICATIONS**

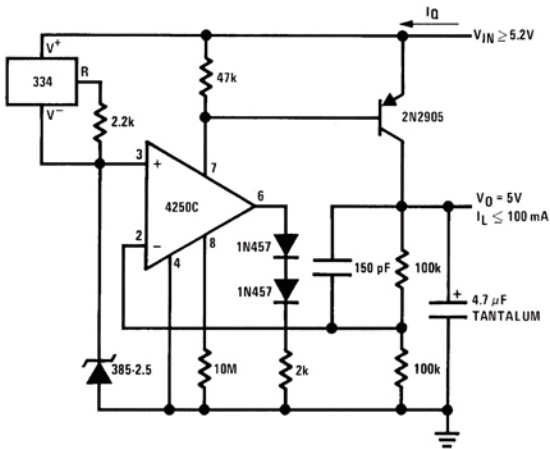


**Figure 15. Wide Input Range Reference**



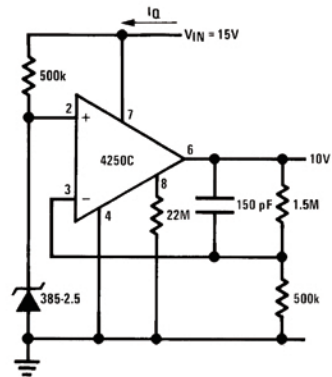
**Figure 16. Micropower Reference from 9V Battery**

**385-2.5-N Applications**



$I_Q = 40 \mu A$

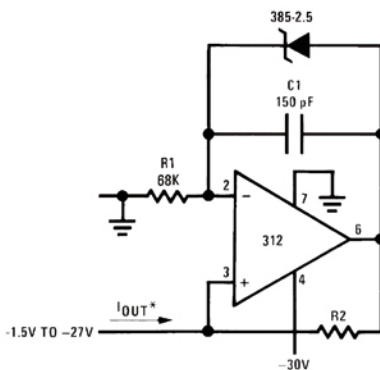
**Figure 17. Micropower 5V Reference**



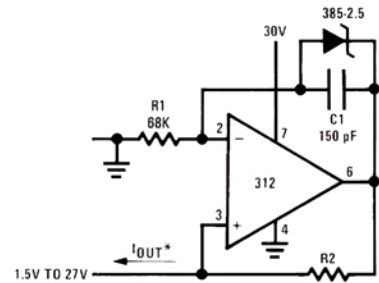
$I_Q \approx 30 \mu A$  standby current

**Figure 18. Micropower 10V Reference**

**PRECISION 1 µA to 1 mA CURRENT SOURCES**

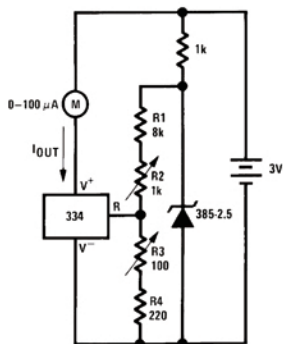


$$I_{OUT} = \frac{2.5V}{R2}$$



**Figure 19.**

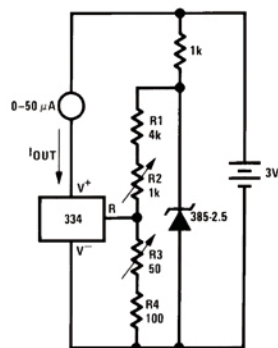
**METER THERMOMETERS**



**Calibration**

1. Short 385-2.5-N, adjust R3 for  $I_{OUT} = \text{temp}$  at  $1 \mu A/^{\circ}K$ .
2. Remove short, adjust R2 for correct reading in centigrade

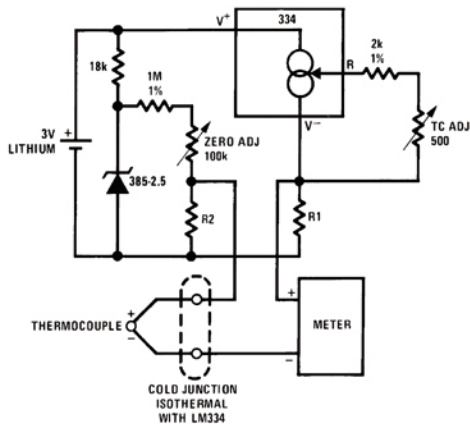
**Figure 20. 0°C–100°C Thermometer**



**Calibration**

1. Short 385-2.5-N, adjust R3 for  $I_{OUT} = \text{temp}$  at  $1.8 \mu A/^{\circ}K$
2. Remove short, adjust R2 for correct reading in  $^{\circ}F$

**Figure 21. 0°F–50°F Thermometer**



**Adjustment Procedure**

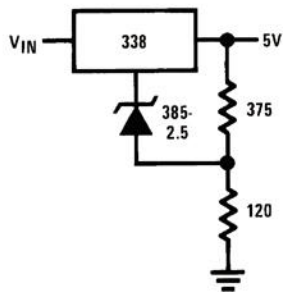
1. Adjust TC ADJ pot until voltage across R1 equals Kelvin temperature multiplied by the thermocouple Seebeck coefficient.
2. Adjust zero ADJ pot until voltage across R2 equals the thermocouple Seebeck coefficient multiplied by 273.2.

**Figure 22. Micropower Thermocouple Cold Junction Compensator**

Thermocouple Type <sup>(1)</sup>	Seebeck Coefficient ( $\mu V/^{\circ}C$ )	R1 ( $\Omega$ )	R2 ( $\Omega$ )	Voltage Across R1 @25°C (mV)	Voltage Across R2 (mV)
J	52.3	523	1.24k	15.60	14.32
T	42.8	432	1k	12.77	11.78
K	40.8	412	953 $\Omega$	12.17	11.17
S	6.4	63.4	150 $\Omega$	1.908	1.766

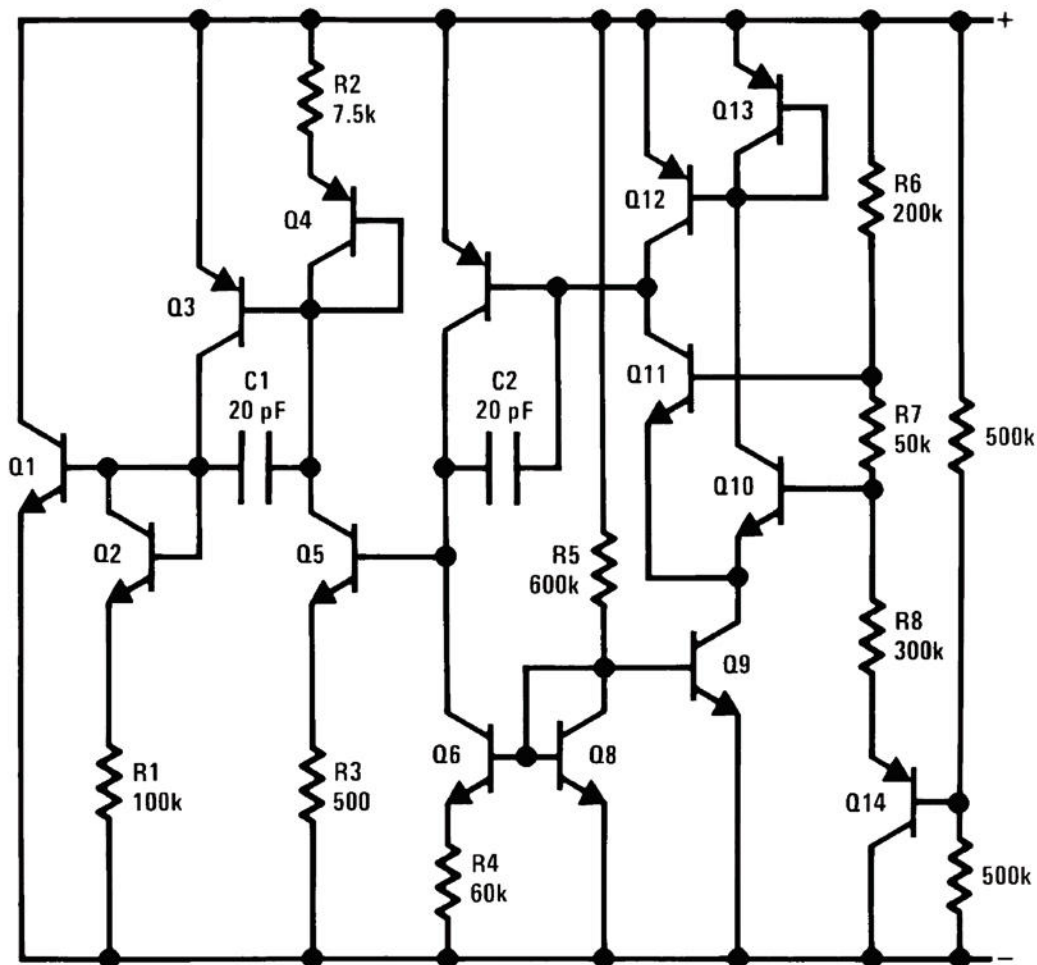
(1) Typical supply current 50  $\mu A$

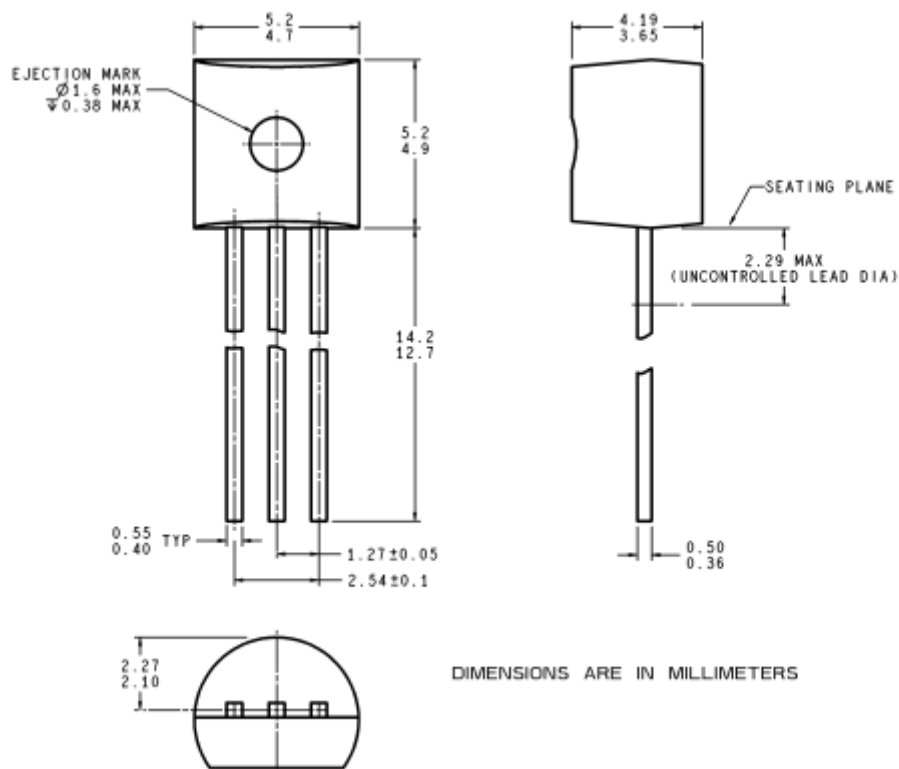




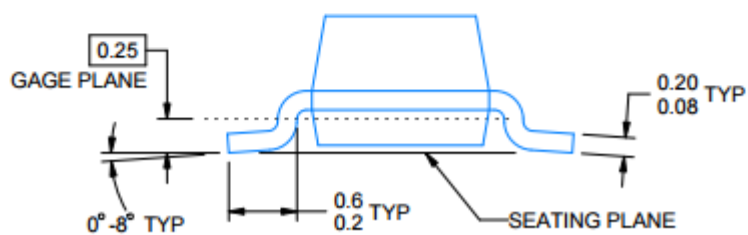
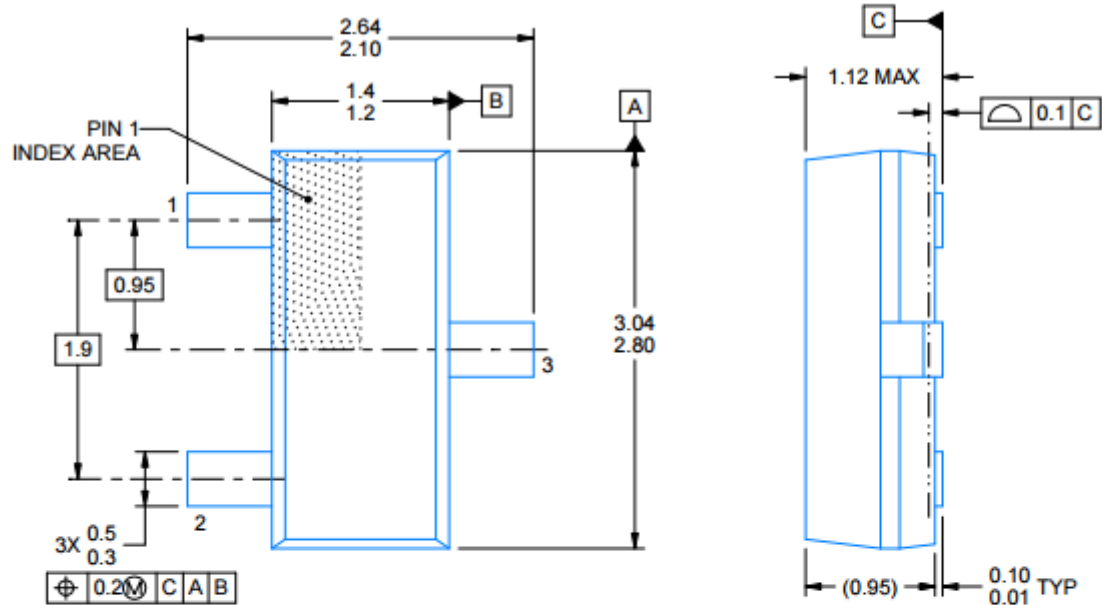
**Figure 23. Improving Regulation of Adjustable Regulators**

**Schematic Diagram**

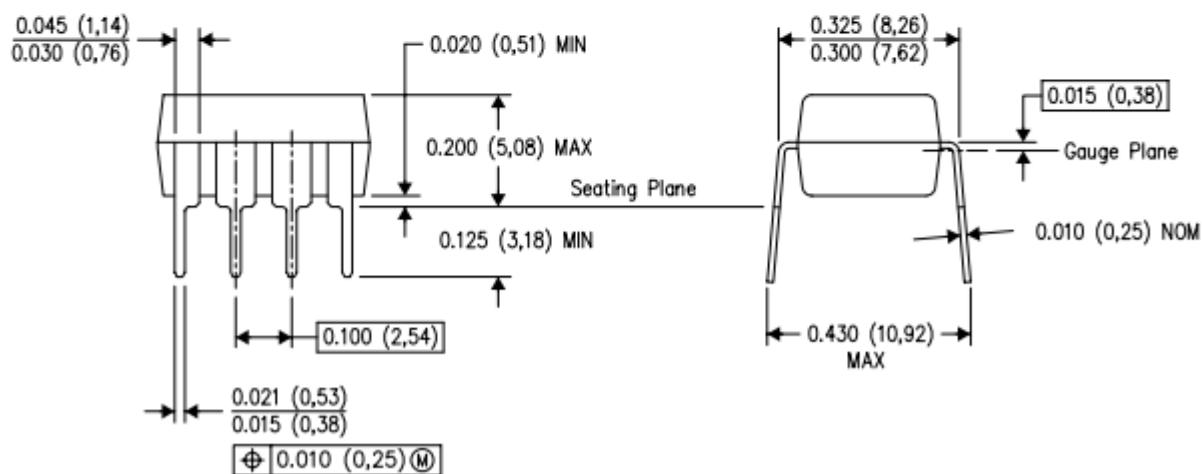
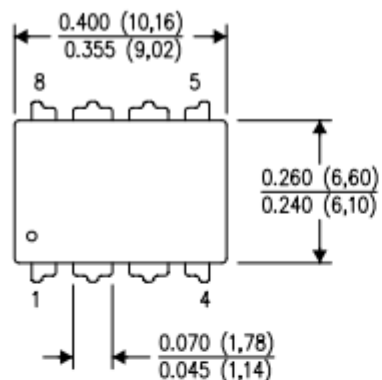




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