LM185-2.5/LM285-2.5/LM385-2.5 Micropower Voltage Reference Diode

FEATURES

- **±20 mV (±0.8%) max. Initial Tolerance (A Grade)**
- **Operating Current of 20 μA to 20 mA**
- **0.6Ω Dynamic Impedance (A Grade)**
- **Low Temperature Coefficient**
- **Low Voltage Reference—2.5V**
- **1.2V Device and Adjustable Device Also Available—LM185-1.2 Series and LM185 Series, respectively**

DESCRIPTION

The LM185-2.5/LM285-2.5/LM385-2.5 are micropower 2-terminal band-gap voltage regulator diodes. Operating over a 20 μA 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 LM-185-2.5 band-gap reference uses only transistors and resistors, low noise and good long term stability result.

Careful design of the LM185-2.5 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 LM185-2.5 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 LM185-1.2.

Connection Diagram

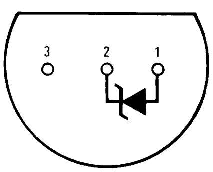


Figure 1. TO-92 Package (Bottom View)

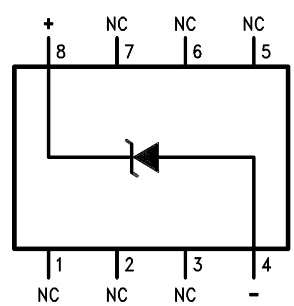
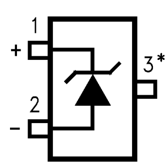


Figure 2. SOIC Package



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

Figure 3. SOT-23

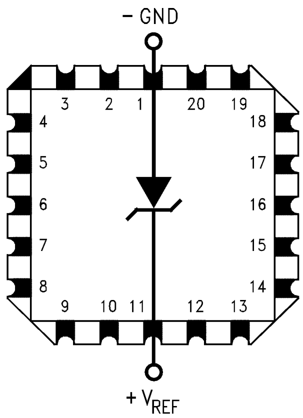


Figure 4. LCCC Leadless Chip Carrier

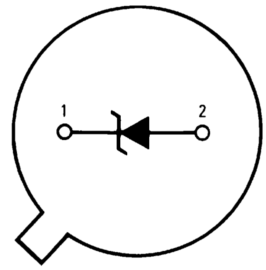


Figure 5. TO Package (Bottom View)

ABSOLUTE MAXIMUM RATINGS[(1)(2)(3)]

Reverse Current			30 mA
Forward Current			10 mA
Operating Temperature Range[(4)]	LM185-2.5		−55°C to + 125°C
	LM285-2.5		−40°C to + 85°C
	LM385-2.5		0°C to 70°C
ESD Susceptibility[(5)]			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

(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, $T_{J\ MAX}$ is:
LM185-2.5: 150°C
LM285-2.5: 125°C
LM385-2.5: 100°C
(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	LM185	150°C	SOIC-8	SOT-23
	LM285	125°C		
	LM385	100°C		
	TO-92	TO		
θ_{ja} (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_{jc} (Junction to Case)	N/A	80°C/W	N/A	N/A

ELECTRICAL CHARACTERISTICS

Parameter	Conditions	Typ	LM385A-2.5 LM385AX-2.5 LM385AY-2.5 Tested Limit[(2)]	 Design Limit[(3)]	Units (Limits)
Reverse Breakdown Voltage	I_R = 100 µA	2.500 **2.500**	2.480 2.520	 **2.470** **2.530**	V(Min) V(Max) V(Min) V(Max)
Minimum Operating Current		12	18	**20**	µA (Max)
Reverse Breakdown Voltage Change with Current	$I_{MIN} \le I_R \le$ 1mA 1 mA ≤ I_R ≤ 20 mA		1 10	**1.5** **20**	mV (Max) mV (Max)
Reverse Dynamic Impedance	I_R = 100 µA, f = 20 Hz	0.2		0.6 **1.5**	Ω
Wideband Noise (rms)	I_R = 100 µA 10 Hz ≤ f ≤ 10 kHz	120			µV
Long Term Stability	I_R = 100 µA, T = 1000 Hr, T_A = 25°C ±0.1°C	20			ppm
Average Temperature Coefficient[(4)]	$I_{MIN} \le I_R \le$ 20 mA X Suffix Y Suffix All Others		 **30** **50** 	 **150**	 ppm/°C (Max)

(1) Parameters identified with boldface type apply at temperature extremes. All other numbers apply at $T_A = T_J$ = 25°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_{MAX} and T_{MIN}, divided by $T_{MAX}–T_{MIN}$. The measured temperatures are −55°C, −40°C, 0°C, 25°C, 70°C, 85°C, 125°C.

ELECTRICAL CHARACTERISTICS

Parameter	Conditions	Typ	LM185-2.5 LM185BX-2.5 LM185BY-2.5 LM285-2.5 LM285BX-2.5 LM285BY-2.5		LM385B-2.5 LM385BX-2.5 LM385BY-2.5		LM385-2.5		Units (Limit)
			Tested Limit (1)(2)	Design Limit (3)	Tested Limit (1)	Design Limit (3)	Tested Limit (1)	Design Limit (3)	
Reverse Breakdown Voltage	T_A = 25°C, 20 μA ≤ I_R ≤ 20 mA	2.5	2.462 2.538		2.462 2.538		2.425 2.575		V(Min) V(Max)
Minimum Operating Current		13	20	**30**	20	**30**	20	**30**	μA (Max)
	LM385M3-2.5						15	**20**	
Reverse Breakdown Voltage Change with Current	20 μA ≤ I_R ≤ 1 mA		1	**1.5**	2.0	**2.5**	2.0	**2.5**	mV (Max)
	1 mA ≤ I_R ≤ 20 mA		10	**20**	20	**25**	20	**25**	mV (Max)
Reverse Dynamic Impedance	I_R = 100 μA, f = 20 Hz	1							Ω
Wideband Noise (rms)	I_R = 100 μA, 10 Hz ≤ f ≤ 10 kHz	120							μV
Long Term Stability	I_R = 100 μA, T = 1000 Hr, T_A = 25°C ±0.1°C	20							ppm
Average Temperature Coefficient (4)	I_R = 100 μA								
	X Suffix		**30**		**30**				ppm/°C
	Y Suffix		**50**		**50**				ppm/°C
	All Others			**150**		**150**		**150**	ppm/°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°C, −40°C, 0°C, 25°C, 70°C, 85°C, 125°C.

TYPICAL PERFORMANCE CHARACTERISTICS

Reverse Characteristics

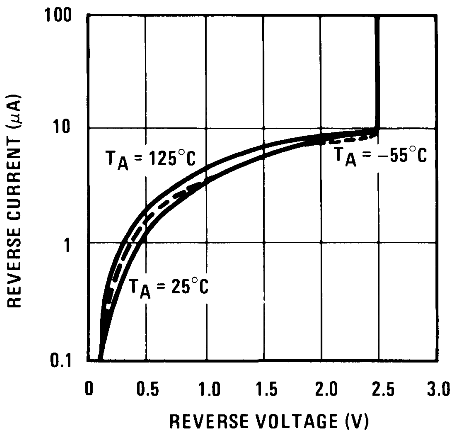


Figure 6.

Reverse Characteristics

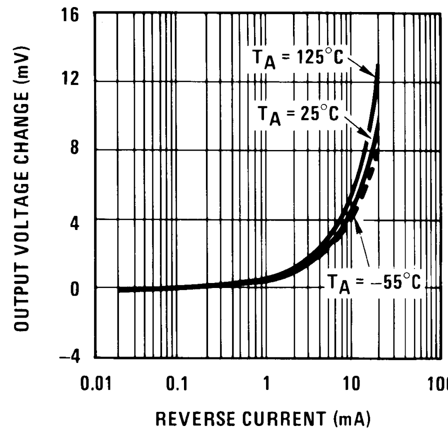


Figure 7.

Forward Characteristics

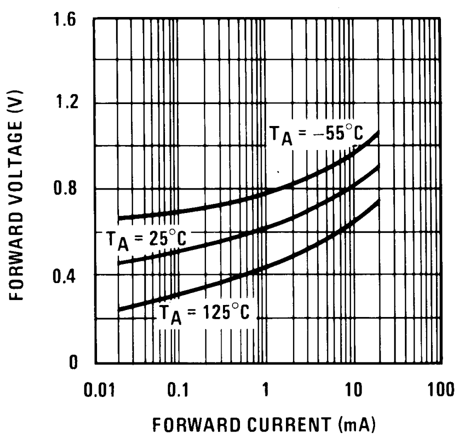


Figure 8.

Temperature Drift

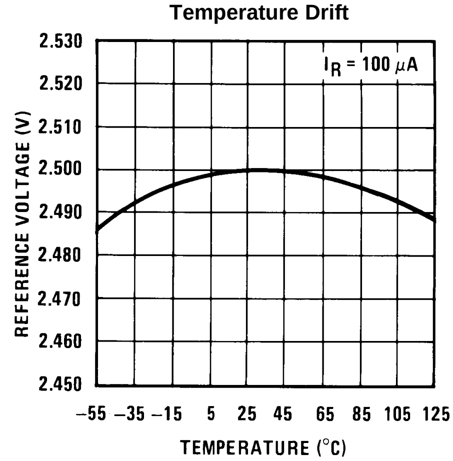


Figure 9.

Reverse Dynamic Impedance

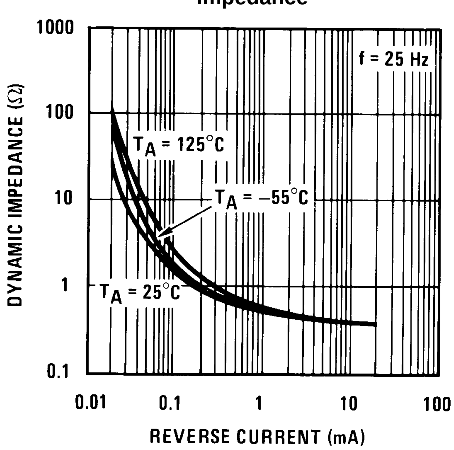


Figure 10.

Reverse Dynamic Impedance

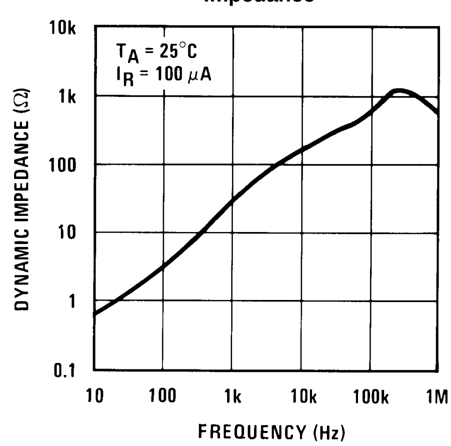


Figure 11.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Noise Voltage

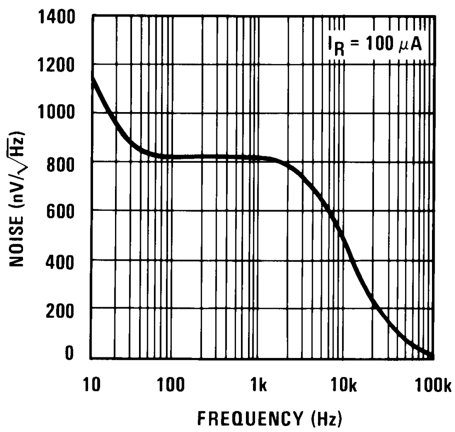


Figure 12.

Filtered Output Noise

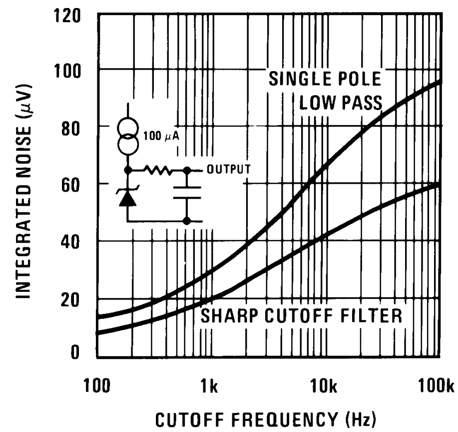


Figure 13.

Response Time

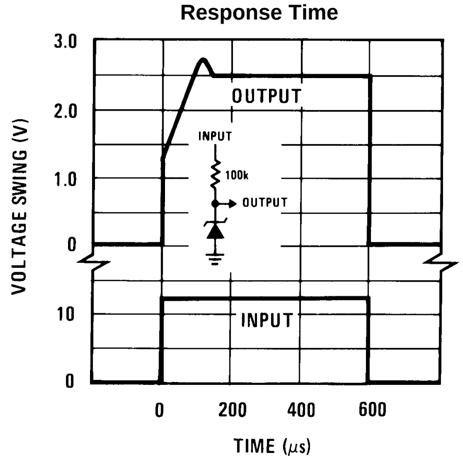


Figure 14.

APPLICATIONS

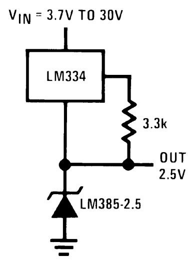


Figure 15. Wide Input Range Reference

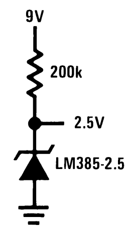
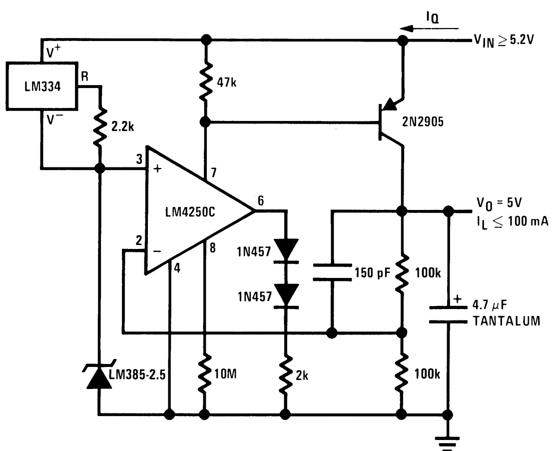


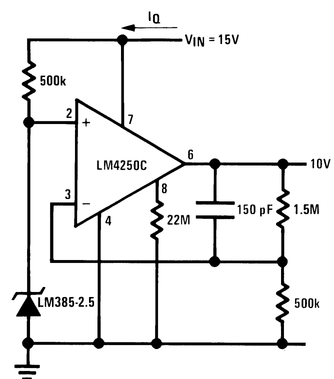
Figure 16. Micropower Reference from 9V Battery

LM385-2.5 Applications



$I_Q \simeq 40\ \mu A$

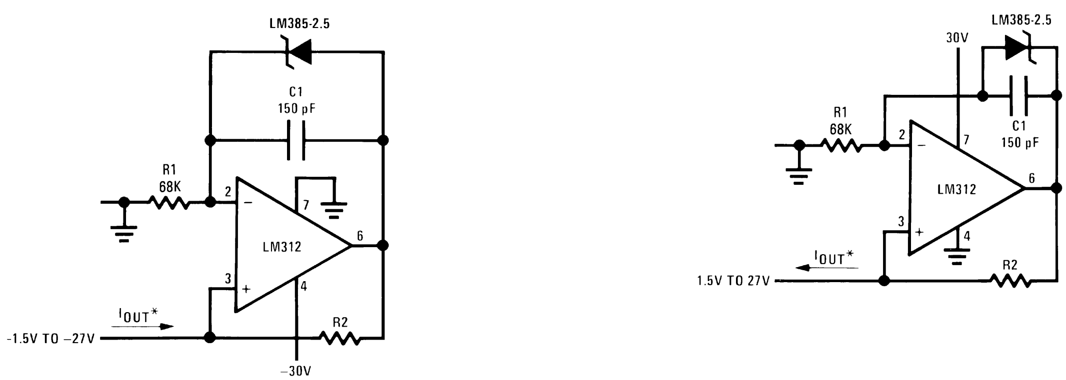
Figure 17. Micropower 5V Reference



$I_Q \simeq 30\ \mu A$ standby current

Figure 18. Micropower 10V Reference

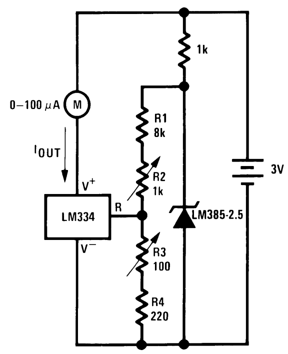
PRECISION 1 µA to 1 mA CURRENT SOURCES



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

Figure 19.

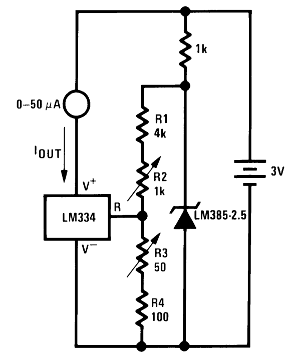
METER THERMOMETERS



Calibration

1. Short LM385-2.5, adjust R3 for I_{OUT}=temp at 1μA/°K.
2. Remove short, adjust R2 for correct reading in centigrade

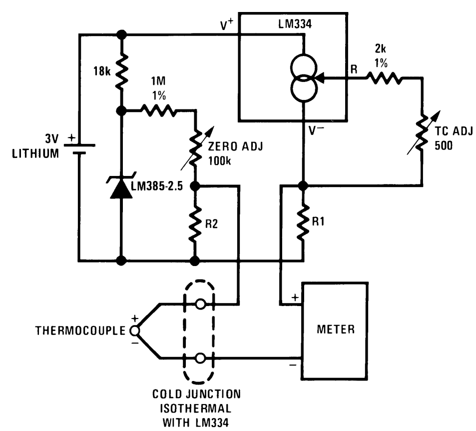
Figure 20. 0°C–100°C Thermomemter



Calibration

1. Short LM385-2.5, adjust R3 for I_{OUT}=temp at 1.8 μA/°K
2. Remove short, adjust R2 for correct reading in °F

Figure 21. 0°F–50°F Thermomemter



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(1)	Seebeck Coefficient (μV/°C)	R1 (Ω)	R2 (Ω)	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	953Ω	12.17	11.17
S	6.4	63.4	150Ω	1.908	1.766

(1) Typical supply current 50 μA

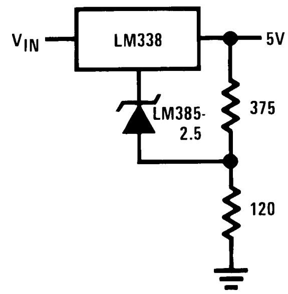
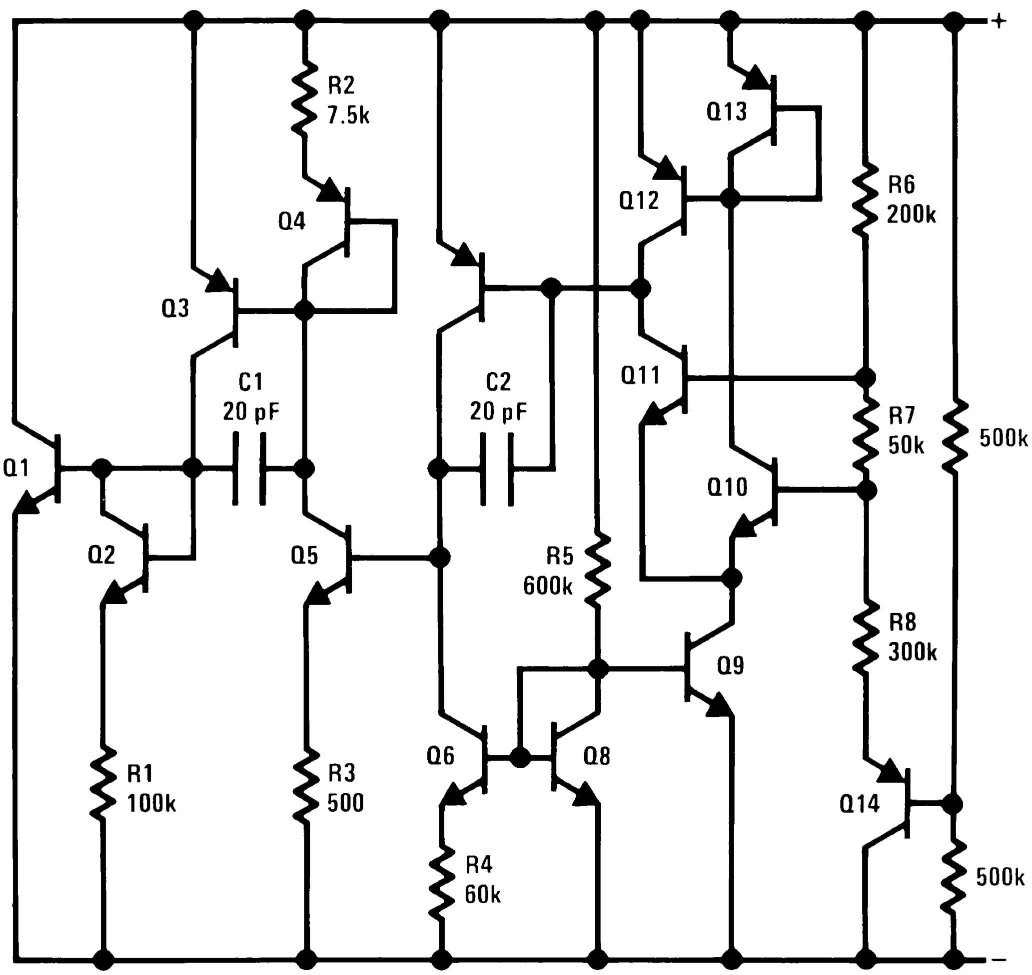


Figure 23. Improving Regulation of Adjstable Regulators

Schematic Diagram



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