



**National
Semiconductor
Corporation**

LM185-1.2/LM285-1.2/LM385-1.2 Micropower Voltage Reference Diode

General Description

The LM185-1.2/LM285-1.2/LM385-1.2 are micropower 2-terminal band-gap voltage regulator diodes. Operating over a 10 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 LM185-1.2 band-gap reference uses only transistors and resistors, low noise and good long term stability result.

Careful design of the LM185-1.2 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 LM185-1.2 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.

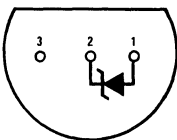
The LM185-1.2 is rated for operation over a -55°C to 125°C temperature range while the LM285-1.2 is rated -40°C to 85°C and the LM385-1.2 0°C to 70°C . The LM185-1.2/LM285-1.2 are available in a hermetic TO-46 package and the LM285-1.2/LM385-1.2 are also available in a low-cost TO-92 molded package, as well as S.O.

Features

- Operating current of 10 μA to 20 mA
- 1% and 2% initial tolerance
- 1 Ω dynamic impedance
- Low temperature coefficient
- Low voltage reference—1.235V
- 2.5V device also available—LM385-2.5

Connection Diagrams

TO-92
Plastic Package (Z)

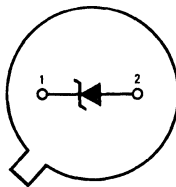


TL/H/5518-10

Bottom View

Order Number LM385Z-1.2,
LM385BZ-1.2, LM385BXZ-1.2,
LM385BYZ-1.2, LM285BXZ-1.2,
LM285BYZ-1.2 or LM285Z-1.2
See NS Package Number Z03A

TO-46
Metal Can Package (H)

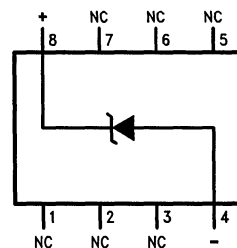


TL/H/5518-6

Bottom View

Order Number LM185H-1.2,
LM185BXH-1.2, LM185BYH-1.2,
LM285H-1.2, LM285BXH-1.2
or LM285BYH-1.2
See NS Package Number H02A

SO Package

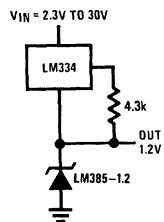


TL/H/5518-9

Order Number LM285M-1.2,
LM385M-1.2 or LM385BM-1.2
See NS Package Number M08A

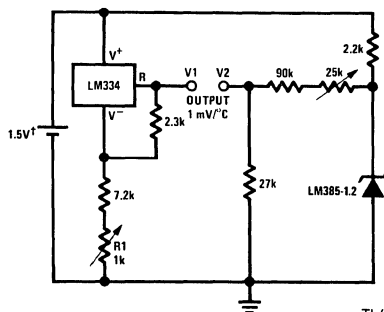
Applications

**Wide Input Range
Reference**



TL/H/5518-8

Centigrade Thermometer



TL/H/5518-1

Calibration

1. Adjust R1 so that $V_1 = \text{temp at } 1 \text{ mV}/^{\circ}\text{K}$
2. Adjust V2 to 273.2 mV

I_Q for 1.3V to 1.6V battery voltage = 50 μA to 150 μA

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, contact the National Semiconductor Sales Office/Distributors for availability and specifications.
(Note 6)

Reverse Current 30mA
Forward Current 10mA

Operating Temperature Range

LM185-1.2 -55°C to + 125°C
LM285-1.2 -40°C to + 85°C
LM385-1.2 0°C to 70°C

Storage Temperature -55°C to + 150°C

Soldering information

TO-92 package: 10 sec. 260°C
TO-46 package: 10 sec. 300°C
SO package: Vapor phase (60 sec.) 215°C
Infrared (15 sec.) 220°C

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" (appendix D) for other methods of soldering surface mount devices.

Electrical Characteristics (Note 1)

Parameter	Conditions	LM185-1.2 LM185BX-1.2 LM185BY-1.2 LM285-1.2 LM285BX-1.2 LM285BY-1.2			LM385-1.2 LM385B-1.2 LM385BX-1.2 LM385BY-1.2			Units Limit
		Typ	Tested Limit (Note 2)	Design Limit (Note 3)	Typ	Tested Limit (Note 2)	Design Limit (Note 3)	
Reverse Breakdown Voltage	$T_A = 25^\circ\text{C}$, $I_{MIN} \leq I_R \leq I_{MAX}$ LM185-1.2/LM285-1.2/LM385B-1.2 LM385-1.2	1.235	1.223 1.247		1.235 1.235	1.223 1.247 1.205 1.260		V_{MIN} V_{MAX} V_{MIN} V_{MAX}
Minimum Operating Current		8	10	20	8	15	20	μA
Reverse Breakdown	$I_{MIN} \leq I_R \leq 1 \text{ mA}$		1	1.5		1	1.5	mV
Voltage Change with Current	$1 \text{ mA} \leq I_R \leq 20 \text{ mA}$		10	20		20	25	mV
Reverse Dynamic Impedance	$I_R = 100 \mu\text{A}$, $f = 20 \text{ Hz}$	1			1			Ω
Wideband Noise (rms)	$I_R = 100 \mu\text{A}$ $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	60			60			μV
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			20			ppm
Average Temperature Coefficient (Note 4)	$I_R = 100 \mu\text{A}$ X Series Y Series Other Versions		30 50	150		30 50	150	ppm/ $^\circ\text{C}$ ppm/ $^\circ\text{C}$ ppm/ $^\circ\text{C}$

Note 1: Parameters identified with **boldface type** apply at temperature extremes and for $I_{MIN} < I_R < 20 \text{ mA}$, unless otherwise specified. All other numbers apply at $T_A = T_J = 25^\circ\text{C}$.

Note 2: Guaranteed and 100% production tested.

Note 3: Guaranteed (but not 100% production tested) over the operating temperature and input current ranges. These limits are not to be used to calculate outgoing quality levels.

Note 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.

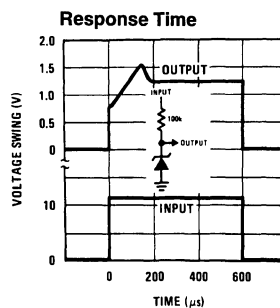
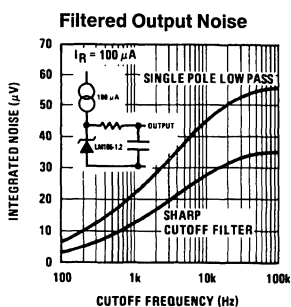
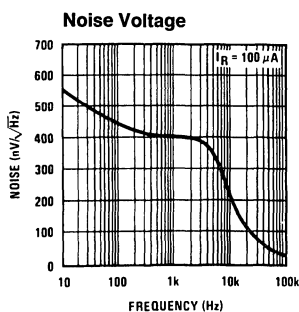
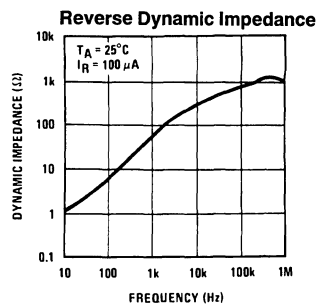
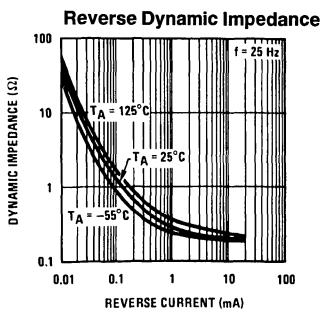
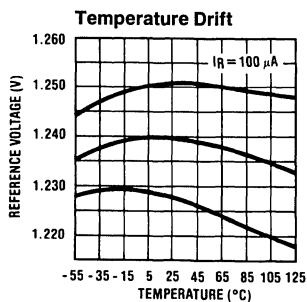
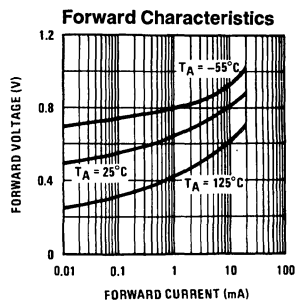
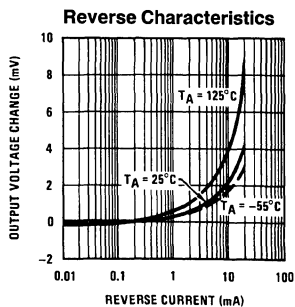
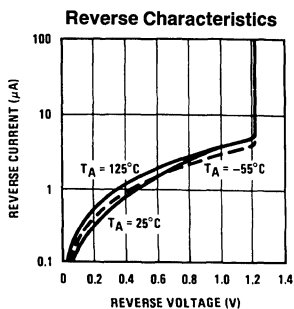
Note 5: For elevated temperature operation, T_J max is:

LM185 150°C
LM285 125°C
LM385 100°C

Thermal Resistance	TO-92	TO-46	SO-8
θ_{JA} (junction to ambient)	180°C/W (0.4" leads) 170°C/W (0.125" leads)	440°C/W	165°C/W
θ_{JC} (junction to case)	n/a	80°C/W	n/a

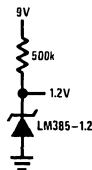
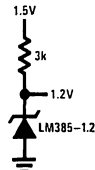
Note 6: Refer to RETS185H-1.2 for military specifications.

Typical Performance Characteristics



TL/H/5518-3

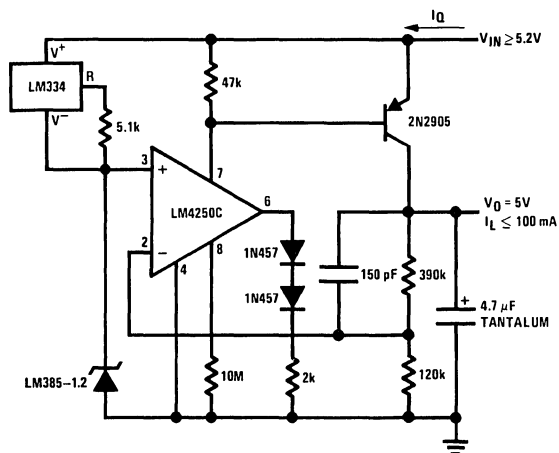
Applications (Continued)

Micropower Reference
from 9V BatteryReference from
1.5V Battery

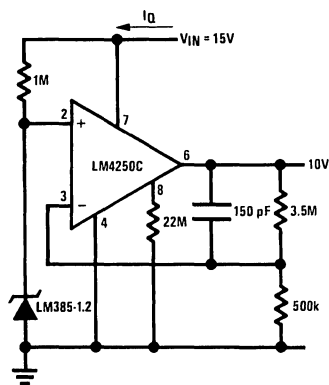
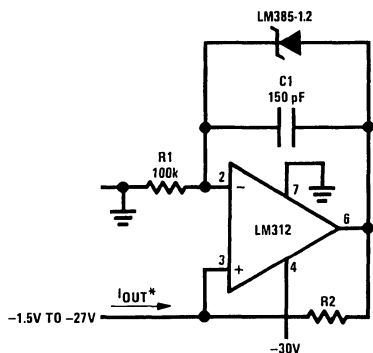
TL/H/5518-2

LM385 Applications

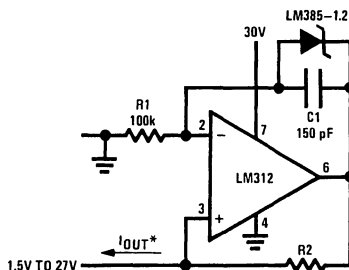
Micropower* 5V Regulator

* $I_Q \approx 30 \mu A$

Micropower* 10V Reference

* $I_Q \approx 20 \mu A$ standby currentPrecision 1 μA to 1 mA Current Sources

$$*I_{OUT} = \frac{1.23V}{R2}$$

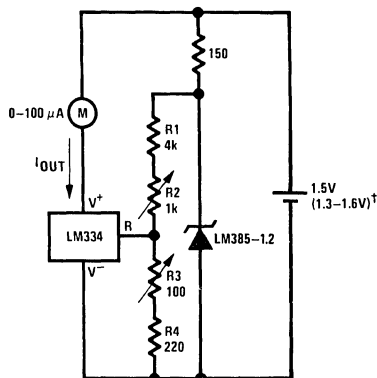


TL/H/5518-4

LM385 Applications (Continued)

METER THERMOMETERS

0°C – 100°C Thermometer



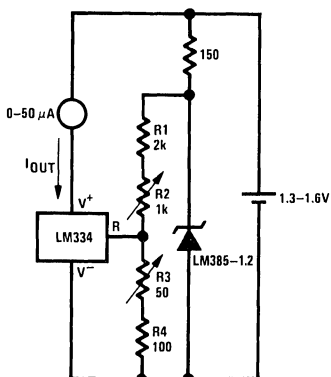
Calibration

1. Short LM385-1.2, adjust R3 for $I_{OUT} = \text{temp at } 1 \mu\text{A}/^\circ\text{K}$
2. Remove short, adjust R2 for correct reading in centigrade

† I_Q at 1.3V $\approx 500 \mu\text{A}$

I_Q at 1.6V $\approx 2.4 \text{ mA}$

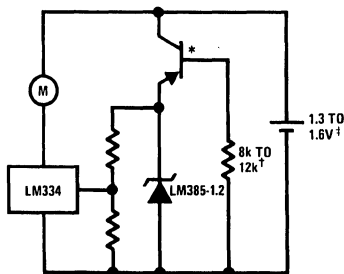
0°F – 50°F Thermometer



Calibration

1. Short LM385-1.2, adjust R3 for $I_{OUT} = \text{temp at } 1.8 \mu\text{A}/^\circ\text{K}$
2. Remove short, adjust R2 for correct reading in °F

Lower Power Thermometer

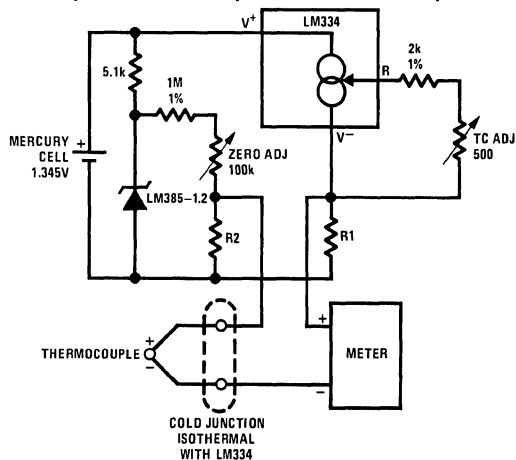


* 2N3638 or 2N2907 select for inverse $H_{FE} \approx 5$

† Select for operation at 1.3V

‡ $I_Q \approx 600 \mu\text{A}$ to $900 \mu\text{A}$

Micropower Thermocouple Cold Junction Compensator



TL/H/5518-5

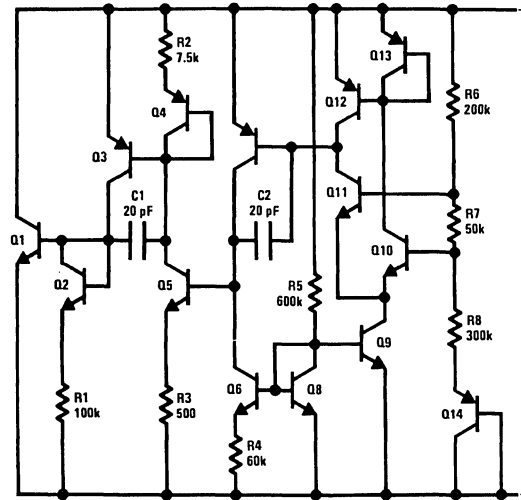
Adjustment Procedure

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.

Thermocouple Type	Seebeck Coefficient ($\mu\text{V}/^\circ\text{C}$)	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	953 Ω	12.17	11.17
S	6.4	63.4	150 Ω	1.908	1.766

Typical supply current 50 μA

Schematic Diagram



TL/H/5518-7