Nanopower Precision Shunt Voltage Reference

FEATURES

- **Initial Voltage Accuracy: 0.05%**
- **Low Operating Current: 800nA**
- **Low Drift: 10ppm/°C Max**
- Less Than 1Ω Dynamic Impedance
- Available in 1.25V, 2.5V, 4.096V and 5V SO-8 Packages

APPLICATIONS

- Portable Meters
- Precision Regulators
- A/D and D/A Converters
- Calibrators

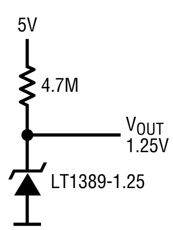
DESCRIPTION

The LT®1389 is a nanopower, precision shunt voltage reference. The bandgap reference uses trimmed precision thin-film resistors and improved curvature correction techniques to achieve 0.05% initial voltage accuracy with guaranteed 10ppm/°C maximum temperature drift. Voltage regulation is maintained to an ultralow 800nA operating current. Advances in design, processing and packaging achieve low temperature cycling hysteresis.

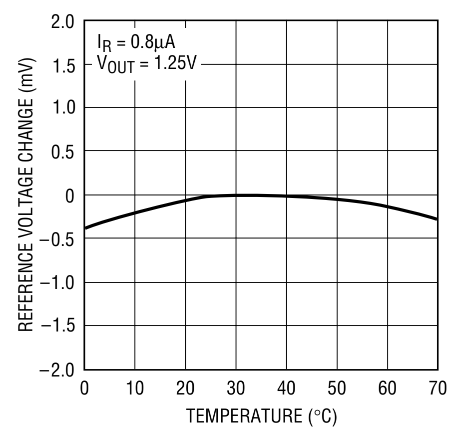
The LT1389 does not require an output compensation capacitor, but is stable with capacitive loads. Low dynamic impedance makes the LT1389 reference easy to use from unregulated supplies.

The LT1389 reference can be used as a high performance upgrade to the LM185/LM385, LT1004, LT1034 and LT1634 where lowest power and guaranteed temperature drift are required.

TYPICAL APPLICATION



Temperature Drift



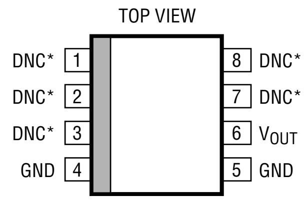
ABSOLUTE MAXIMUM RATINGS

(Note 1)

Operating Current
- 1.25V 20mA
- 2.5V 20mA
- 4.096V 10mA
- 5V 10mA

Forward Current 20mA
Operating Temperature Range .... 0°C to 70°C
Storage Temperature Range (Note 2) ... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

PACKAGE/ORDER INFORMATION



S8 PACKAGE
8-LEAD PLASTIC SO

T_{JMAX} = 125°C, θ_{JA} = 190°C/W

ORDER PART NUMBER
LT1389ACS8-1.25
LT1389BCS8-1.25
LT1389BCS8-2.5
LT1389BCS8-4.096
LT1389BCS8-5

S8 PART MARKING	
389A12	1389B4
389B12	1389B5
389B25	

*Connected internally. Do Not Connect external circuitry to these pins.
Consult factory for Industrial and Military grade parts.

AVAILABLE OPTIONS

TEMPERATURE	OUTPUT VOLTAGE	ACCURACY (%)	TEMPERATURE COEFFICIENT (ppm/°C)	PART TYPE	PART MARKING
0°C to 70°C	1.250	0.05	10	LT1389ACS8-1.25	389A12
	1.250	0.05	20	LT1389BCS8-1.25	389B12
	2.500	0.05	20	LT1389BCS8-2.5	389B25
	4.096	0.075	50	LT1389BCS8-4.096	1389B4
	5.000	0.075	50	LT1389BCS8-5	1389B5

1.25V ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. (Note 3)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Reverse Breakdown Voltage	LT1389ACS8/LT1389BCS8 (I_R = 0.8µA)		1.24937 –0.05	1.250	1.25062 0.05	V %
	LT1389ACS8 (I_R = 0.8µA)	●	1.24849 –0.12	1.250	1.25149 0.12	V %
	LT1389BCS8 (I_R = 0.8µA)	●	1.24762 –0.19	1.250	1.25237 0.19	V %
Reverse Breakdown Change with Current (Note 4)	0.8µA ≤ I_R ≤ 200µA	 ●		0.20 0.20	0.4 1.0	mV mV
	200µA ≤ I_R ≤ 2mA	 ●		0.3 0.3	1.0 2.0	mV mV
Minimum Operating Current		●			0.6	µA
Temperature Coefficient	LT1389ACS8 (I_R = 0.8µA) LT1389BCS8 (I_R = 0.8µA)	● ●		4 4	10 20	ppm/°C ppm/°C
Reverse Dynamic Impedance (Note 5)	0.8µA ≤ I_R ≤ 2mA	 ●		0.25 0.25	0.7 1.5	Ω Ω
Low Frequency Noise (Note 6)	I_R = 0.8µA, 0.1Hz ≤ f ≤ 10Hz			25		μV_{P-P}

2.5V ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. (Note 3)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Reverse Breakdown Voltage	LT1389BCS8 (I_R = 0.9μA)		2.49875 −0.05	2.500	2.50125 0.05	V %
	LT1389BCS8 (I_R = 0.9μA)	●	2.49525 −0.19	2.500	2.50475 0.19	V %
Reverse Breakdown Change with Current (Note 4)	0.9μA ≤ I_R ≤ 200μA	 ●		0.2 0.2	0.5 1.5	mV mV
	200μA ≤ I_R ≤ 2mA	 ●		0.3 0.3	1.0 2.5	mV mV
Minimum Operating Current		●			0.7	μA
Temperature Coefficient	I_R = 0.9μA	●		8	20	ppm/°C
Reverse Dynamic Impedance (Note 5)	0.9μA ≤ I_R ≤ 2mA	 ●		0.25 0.25	0.75 2	Ω Ω
Low Frequency Noise (Note 6)	I_R = 0.9μA, 0.1Hz ≤ f ≤ 10Hz			50		$μV_{P-P}$

4.096V ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. (Note 3)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Reverse Breakdown Voltage	LT1389BCS8 (I_R = 1.5μA)		4.09293 −0.075	4.096	4.09907 0.075	V %
	LT1389BCS8 (I_R = 1.5μA)	●	4.0788 −0.42	4.096	4.1132 0.42	V %
Reverse Breakdown Change with Current (Note 4)	1.5μA ≤ I_R ≤ 200μA	 ●		0.2 0.2	1.5 3	mV mV
	200μA ≤ I_R ≤ 2mA	 ●		0.3 0.3	4 6	mV mV
Minimum Operating Current		●			1	μA
Temperature Coefficient	I_R = 1.5μA	●		12	50	ppm/°C
Reverse Dynamic Impedance (Note 5)	1.5μA ≤ I_R ≤ 2mA	 ●		0.75 0.75	2 3	Ω Ω
Low Frequency Noise (Note 6)	I_R = 1.5μA, 0.1Hz ≤ f ≤ 10Hz			80		$μV_{P-P}$

5V ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. (Note 3)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Reverse Breakdown Voltage	LT1389BCS8 (I_R = 1.5µA)		4.99625 −0.075	5.000	5.00375 0.075	V %
	LT1389BCS8 (I_R = 1.5µA)	●	4.979 −0.42	5.000	5.021 0.42	V %
Reverse Breakdown Change with Current (Note 4)	1.5µA ≤ I_R ≤ 200µA	 ●		0.2 0.2	1.5 3	mV mV
	200µA ≤ I_R ≤ 2mA	 ●		0.3 0.3	4 6	mV mV
Minimum Operating Current		●			1	µA
Temperature Coefficient	I_R = 1.5µA	●		12	50	ppm/°C
Reverse Dynamic Impedance (Note 5)	1.5µA ≤ I_R ≤ 2mA	 ●		0.75 0.75	2 3	Ω Ω
Low Frequency Noise (Note 6)	I_R = 1.5µA, 0.1Hz ≤ f ≤ 10Hz			100		μV_{P-P}

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: If the part is stored outside of the specific operating temperature range, the output may shift due to hysteresis.

Note 3: ESD (Electrostatic Discharge) sensitive device. Use proper ESD handling precautions.

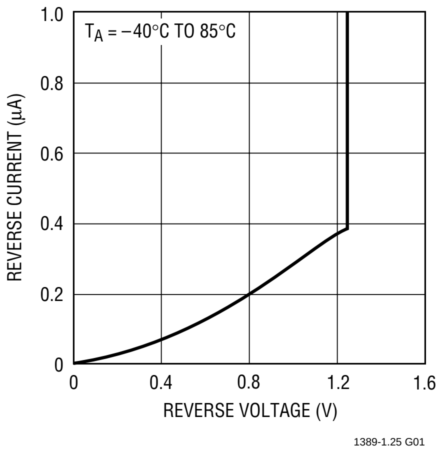
Note 4: Output requires 0.1µF for operating current greater than 1mA.

Note 5: This parameter is guaranteed by "reverse breakdown change with current" test.

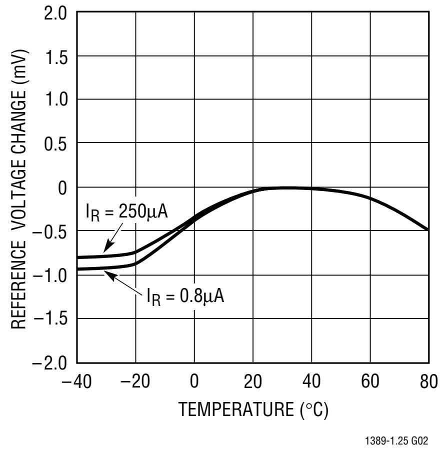
Note 6: Peak-to-peak noise is measured with a single highpass filter at 0.1Hz and 2-pole lowpass filter at 10Hz.

1.25V TYPICAL PERFORMANCE CHARACTERISTICS

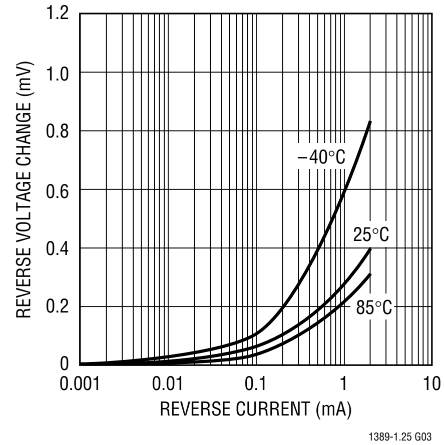
Reverse Characteristics



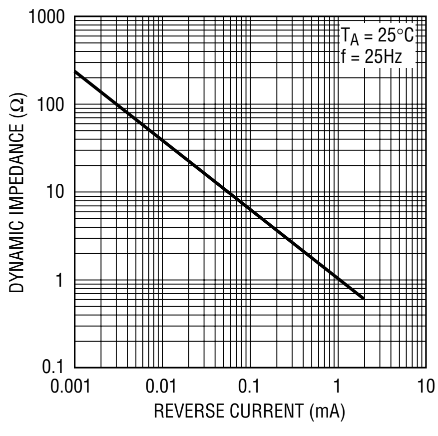
Temperature Drift



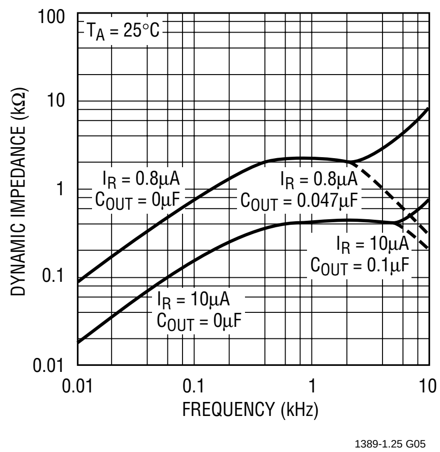
Reverse Voltage Change vs Current



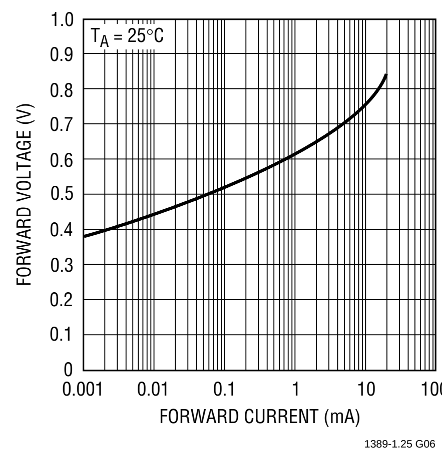
Reverse Dynamic Impedance



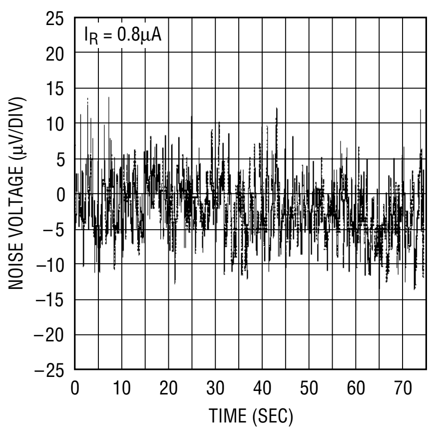
Dynamic Impedance vs Frequency



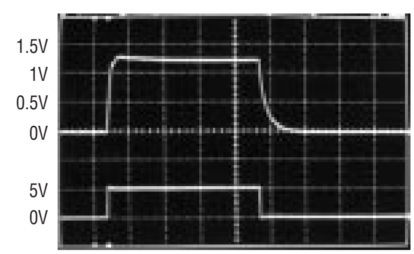
Forward Characteristics



0.1Hz to 10Hz Noise



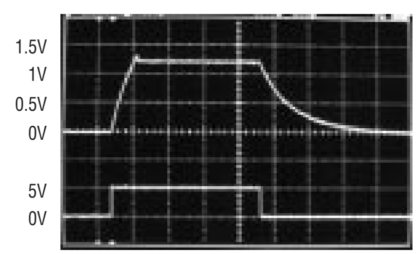
Response Time



I_R = 0.8µA 1ms/DIV
C_{OUT} = 0µF

1389-1.25 G08

Response Time

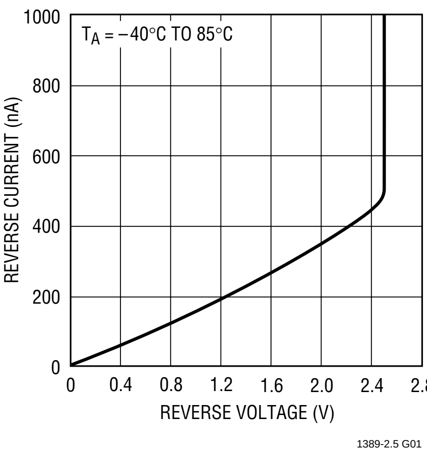


I_R = 0.8µA 200ms/DIV
C_{OUT} = 0.1µF

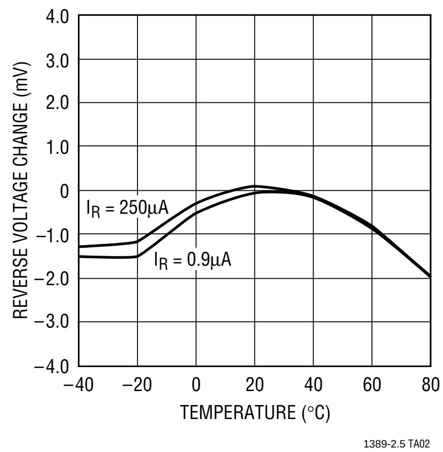
1389-1.25 G09

2.5V TYPICAL PERFORMANCE CHARACTERISTICS

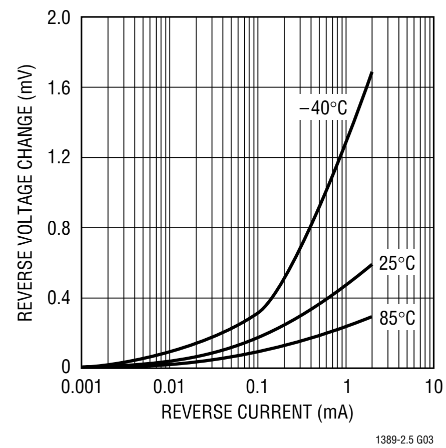
Reverse Characteristics



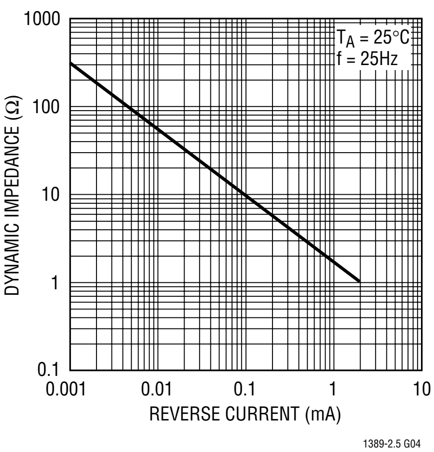
Temperature Drift



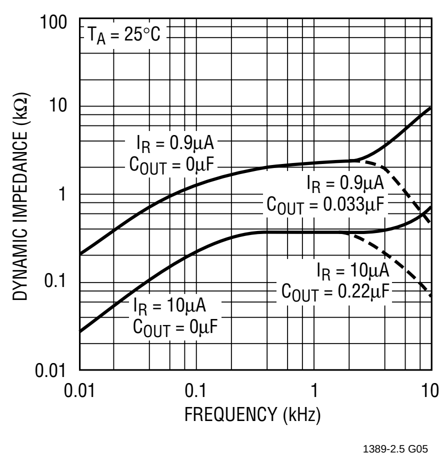
Reverse Voltage Change vs Current



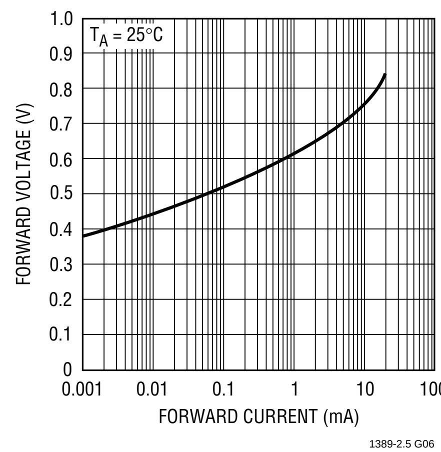
Reverse Dynamic Impedance



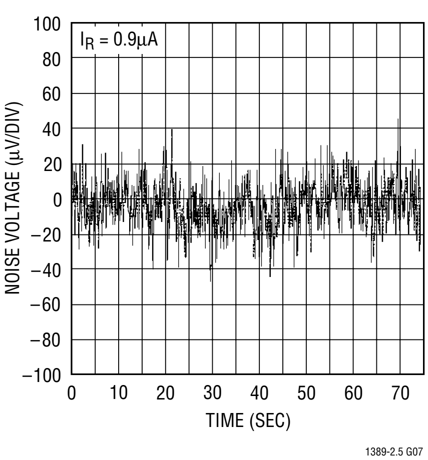
Dynamic Impedance vs Frequency



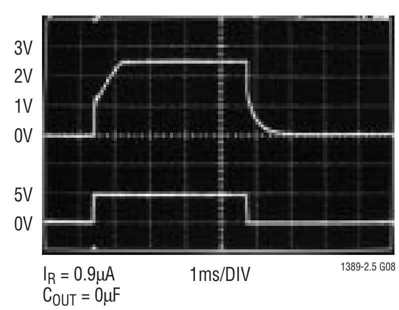
Forward Characteristics



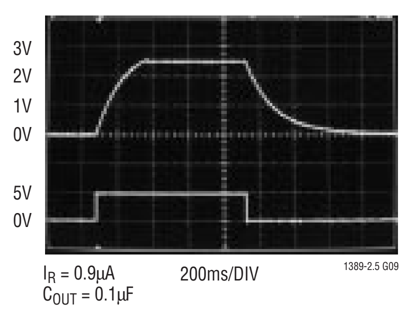
0.1Hz to 10Hz Noise



Response Time

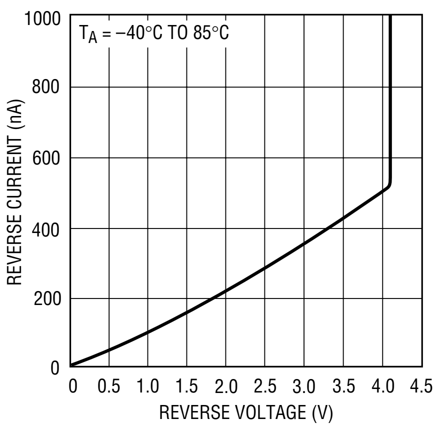


Response Time



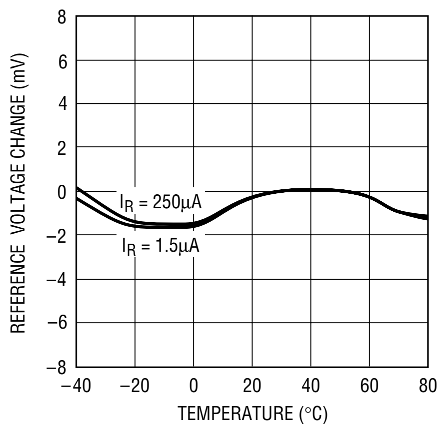
4.096V TYPICAL PERFORMANCE CHARACTERISTICS

Reverse Characteristics



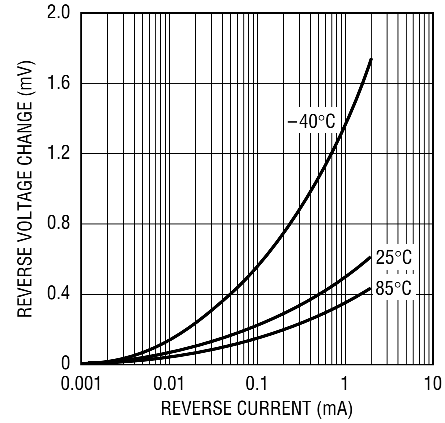
1389-4 G01

Temperature Drift



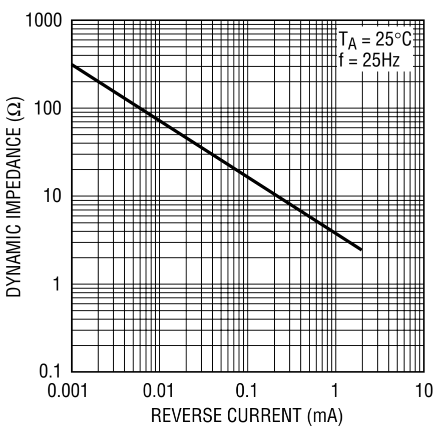
1389-4 G02

Reverse Voltage Change vs Current



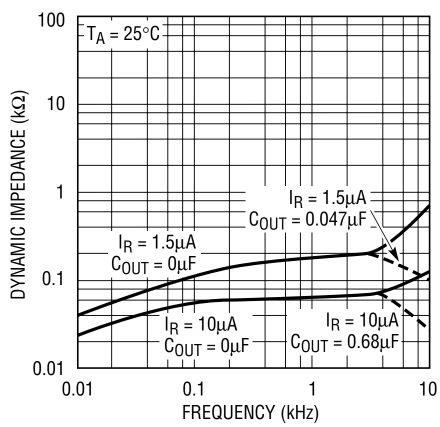
1389-4 G03

Reverse Dynamic Impedance



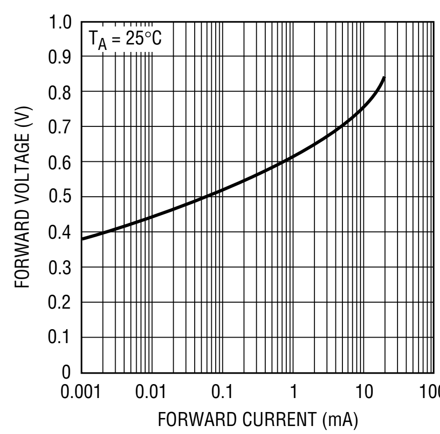
1389-4 G04

Dynamic Impedance vs Frequency



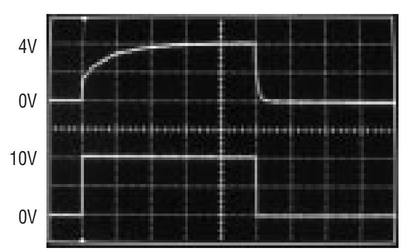
1389-4 G05

Forward Characteristics



1389-4 G06

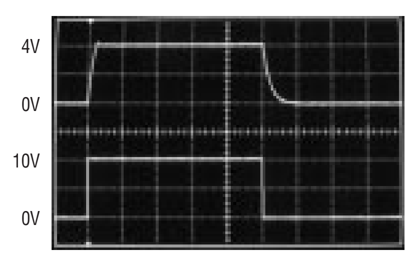
Response Time



I_R = 1.5µA
C_{OUT} = 0µF
2ms/DIV

1389-4 G08

Response Time

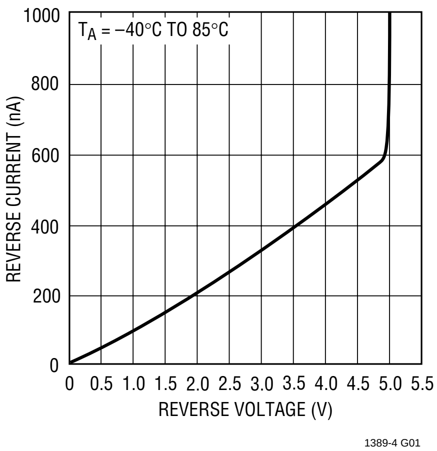


I_R = 1.5µA
C_{OUT} = 0.1µF
200ms/DIV

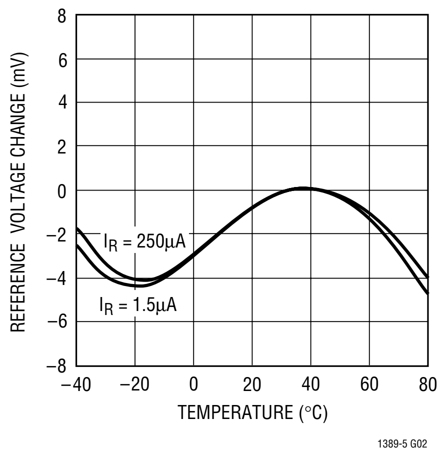
1389-4 G09

5V TYPICAL PERFORMANCE CHARACTERISTICS

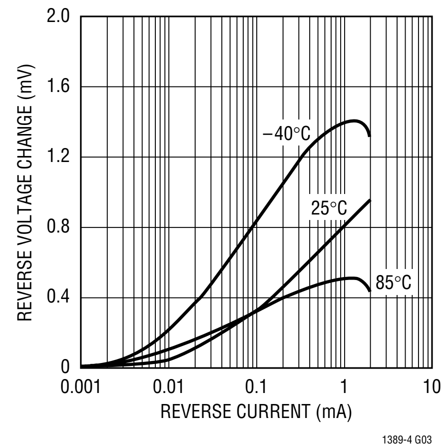
Reverse Characteristics



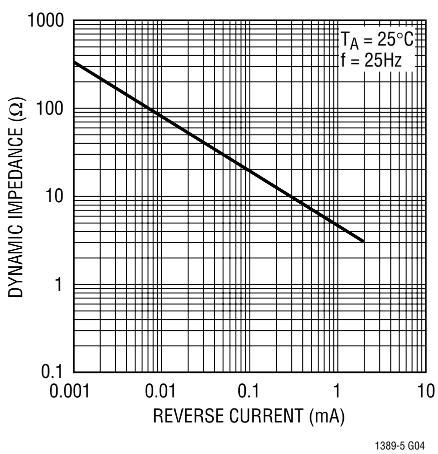
Temperature Drift



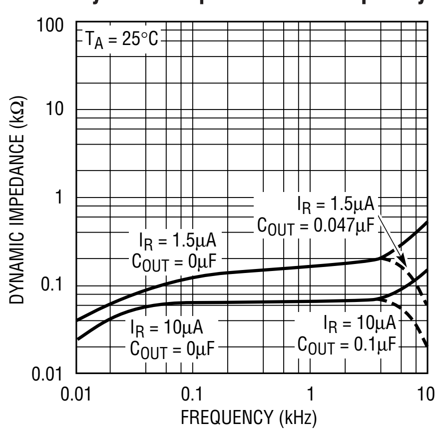
Reverse Voltage Change vs Current



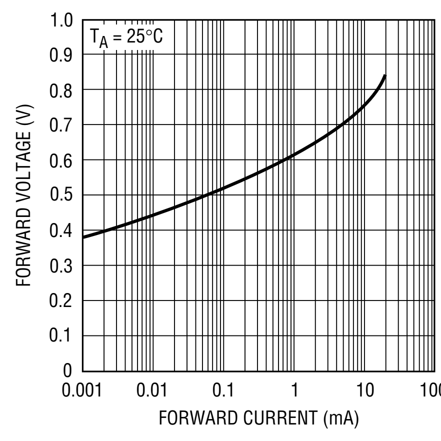
Reverse Dynamic Impedance



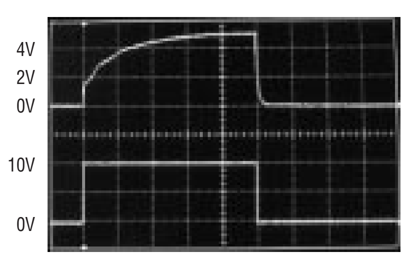
Dynamic Impedance vs Frequency



Forward Characteristics

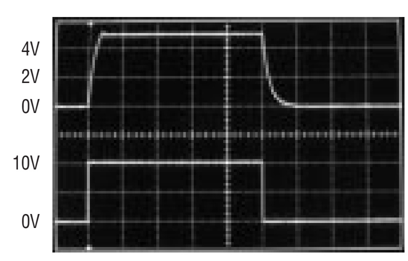


Response Time



I_R = 1.5µA
C_{OUT} = 0µF
2ms/DIV

Response Time



I_R = 1.5µA
C_{OUT} = 0.1µF
200ms/DIV

APPLICATIONS INFORMATION

The reverse characteristics of the LT1389 resembles a simple resistor Zener diode parallel connection. This well behaved characteristic is important to the proper operation of circuits like Figure 1. The adjustable output voltage reference depends upon positive feedback from the LT1495's output to start-up and regulate the bias current for the LT1389. The LT1389 has no negative resistance regions that can interfere with the proper start-up of the buffered reference.

Board leakage is a concern for a nanopower precision shunt voltage reference. The LT1389 requires attention to detail in board layout in order to maximize its performance. 1.5GΩ of leakage between a DNC pin and a 5V supply will conduct 2.5nA which induces a 0.2% error in V_{OUT}. Board leakage can be minimized by encircling the DNC pins with a guard ring operated at a potential of V_{OUT}. By tying the guard ring to V_{OUT} as shown in Figure 2, leakage paths are eliminated.

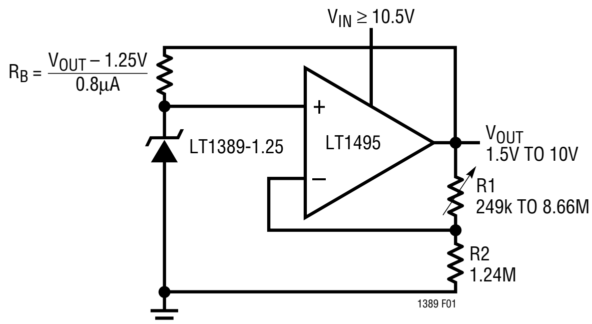


Figure 1. Adjustable Output Voltage Reference

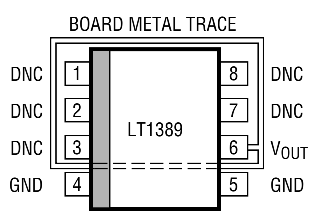
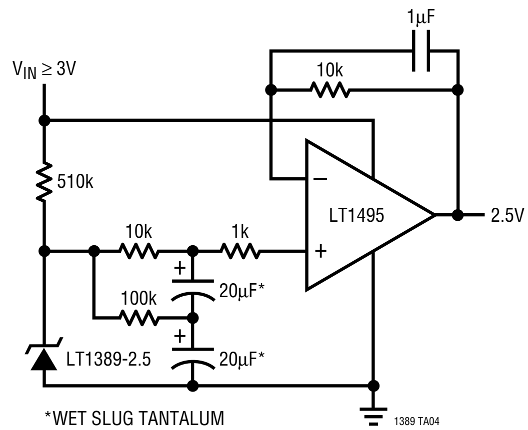


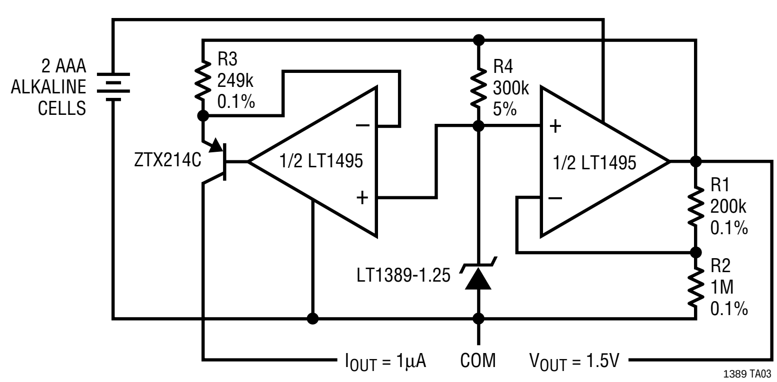
Figure 2. Guard Ring to Reduce Board Leakage

TYPICAL APPLICATIONS

2.5V Output, Low Noise Reference



Micropower Voltage and Current Reference

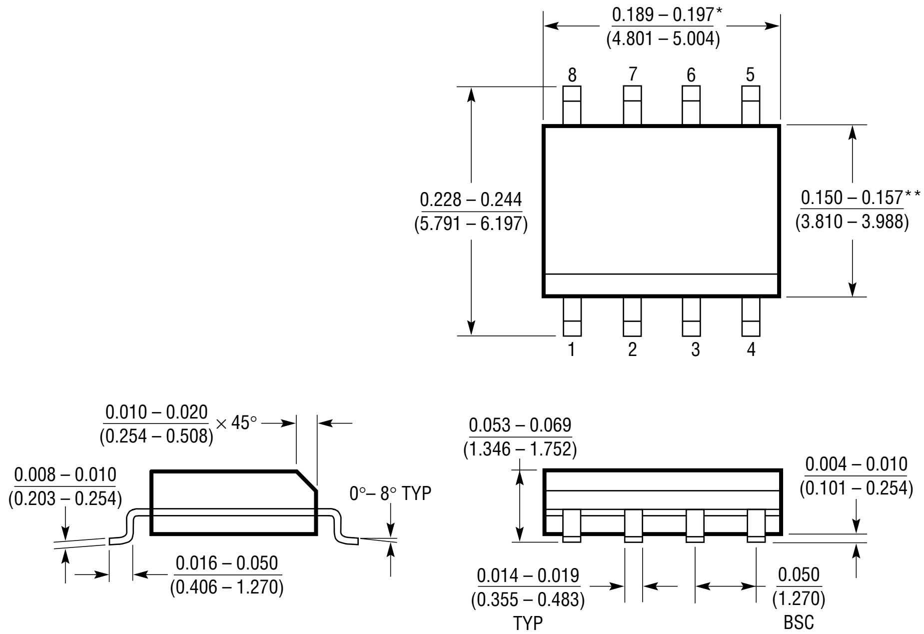


R1 TO R3: MAR5 SERIES, IRC (512) 992-7900

PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

S8 Package
8-Lead Plastic Small Outline (Narrow 0.150)
(LTC DWG # 05-08-1610)



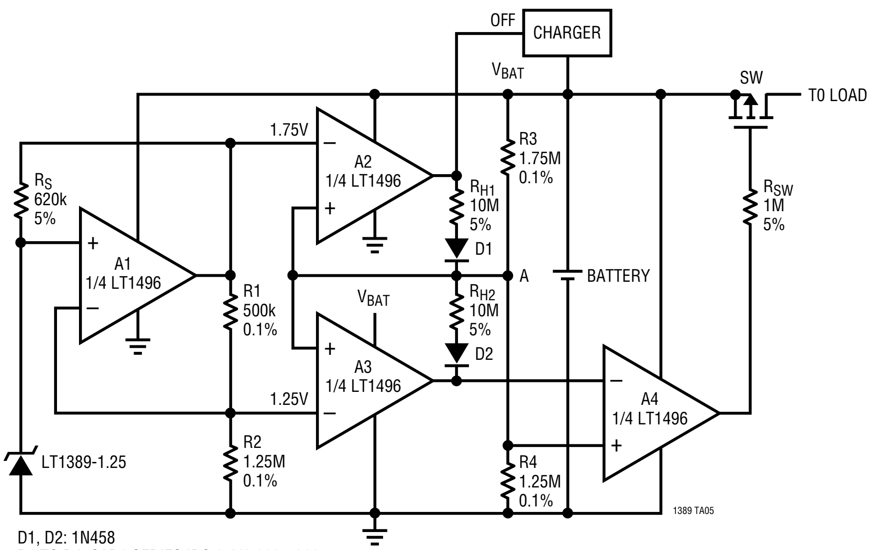
*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

**DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010" (0.254mm) PER SIDE

SO8 1298

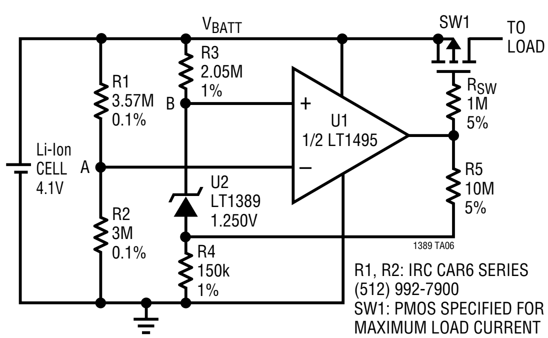
TYPICAL APPLICATIONS

Single Cell Li-Ion Battery Supervisory Circuit, I_Q = 10μA



D1, D2: 1N458
R1 TO R4: CAR6 SERIES IRC (512) 992-7900
SW: PMOS SPECIFIED FOR MAXIMUM LOAD CURRENT

Precision Undervoltage Lockout Circuit



R1, R2: IRC CAR6 SERIES
(512) 992-7900
SW1: PMOS SPECIFIED FOR
MAXIMUM LOAD CURRENT

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC®1440	Micropower Comparator with Reference	3.7μA Max Supply Current, 1% 1.182V Reference, MSOP, PDIP and SO-8 Packages
LT1460	Micropower Series Reference	0.075% Max, 10ppm/°C Max Drift, 2.5V, 5V and 10V Versions, MSOP, PDIP, SO-8, SOT-23 and TO-92 Packages
LT1461	Micropower Precision LDO Series Reference	3ppm/°C Max Drift, 0°C to 70°C, –40°C to 85°C, –40°C to 125°C Options in SO-8
LT1495	1.5μA Precision Rail-to-Rail Dual Op Amp	1.5μA Max Supply Current, 100pA Max I_{OS}
LTC1540	Nanopower Comparator with Reference	600nA Max Supply Current, 2% 1.182V Reference, MSOP and SO-8 Packages
LT1634	Micropower Precision Shunt Voltage Reference	0.05% Max, 10ppm/°C Max Drift, 1.25V, 2.5V, 4.096V, 5V, 10μA Maximum Supply Current
LTC1798	6μA Low Dropout Series Reference	Available in Adjustable, 2.5V, 3V, 4.096V and 5V

Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
(408)432-1900 • FAX: (408) 434-0507 • www.linear-tech.com
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