Evaluation Kit Available | Design Resources | Tools and Models | Support

Click here to ask an associate for production status of specific part numbers.

1µA Ultra-Tiny Shunt Voltage Reference

MAX6069

General Description

The MAX6069 ultra-low-power shunt references are ideal for space-critical and low-power applications. They are offered in a 4-bump wafer-level package (WLP), and the minimum operating current is guaranteed to be less than 1µA. These references feature low temperature coefficients of less than 20ppm/°C and initial accuracy of better than 0.2%.

Available with +1.25V, +2.048V, +2.5V, and 3V output voltages, these references can be used as lower-power, higher-precision upgrades to the ICL8069, LM385, LT1004, and LM4040 in much smaller packages. Two grades are available: A and B. The A grade features a temperature coefficient of 25ppm/°C over the extended temperature range of -40°C to +85°C, with an initial accuracy of 0.2%. Grade B features a temperature coefficient of 50ppm/°C over the extended temperature range of -40°C to +85°C, with an initial accuracy of 0.5%. Their tiny wafer-level packages make these references ideal for equipment with very small form factors.

Applications

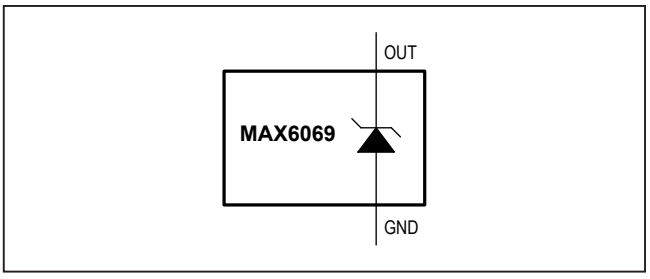
- Portable Sensors
- Portable Meters
- Precision Regulators
- A/D and D/A Converters
- 4mA–20mA Loop-Powered Sensors

Benefits and Features

- Wide Operating Current Range: 1µA to 2mA
- 0.88mm x 1.16mm, 4-Bump WLP
- Initial Voltage Accuracy: 0.2%
- Temperature Coefficient: 20ppm/°C (max)
- Temperature Range: -40°C to +125°C
- Factory-Trimmed Output Voltages: +1.25V, +2.048V, +2.5V, +3.0V
- Functionally Equivalent to the MAX6006/MAX6007/MAX6008/MAX6009

***Ordering Information* appears at end of data sheet.**

Simplified Block Diagram



19-100064; Rev 1; 10/21

© 2021 Analog Devices, Inc. All rights reserved. Trademarks and registered trademarks are the property of their respective owners.

Absolute Maximum Ratings

Operating Current (OUT to GND) 20mA
Forward Current (GND to OUT) 20mA
Continuous Power Dissipation (Multilayer Board; derate 9.75mW/°C above +70°C) 780mW
Operating Temperature Range ..... -40°C to +125°C
Storage Temperature Range ..... -65°C to +150°C
Junction Temperature ..... +150°C
Soldering Temperature (reflow) ..... +260°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Package Information

WLP

Package Code	W40D1+1
Outline Number	21-100139
Land Pattern Number	Refer to Application Note 1891
Thermal Resistance, Four-Layer Board:	
Junction-to-Ambient (θ_{JA})	102.59°C/W
Junction-to-Case (θ_{JC})	N/A

For the latest package outline information and land patterns (footprints), go to www.maximintegrated.com/packages. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to www.maximintegrated.com/thermal-tutorial.

Electrical Characteristics

(T_A=-40°C to +125°C, unless otherwise noted., Typical values are at T_A = +25°C. (Note 1))

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
MAX6069A (1.250V)							
Reverse Breakdown Voltage	V_R	T_A = +25°C, I_R = 1.2µA	MAX6069AA (0.2%)	1.2475	1.2500	1.2525	V
			MAX6069AB (0.5%)	1.2438	1.2500	1.2563	
Minimum Operating Current	I_{RMIN}	V_R change < 0.2% from V_R at I_R = 1.2µA			0.5	1.0	µA
Reverse Breakdown Change with Current		I_R = 1.2µA to 200µA				1	mV
		I_R = 200µA to 2mA				2.0	
Reverse Dynamic Impedance		I_R = 1.2µA to 2mA (Note 2)				1.5	Ω
Low-Frequency Noise		I_R = 1.2µA, f = 0.1Hz to 10Hz			30		µVp-p

Electrical Characteristics (continued)

(T_A=-40°C to +125°C, unless otherwise noted., Typical values are at T_A = +25°C. (Note 1))

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Temperature Coefficient (Note 3)	TC	I_R = 1.2µA, MAX6069AA	T_A = -40°C to +85°C			20	ppm/°C
			T_A = -40°C to +125°C			25	
		I_R = 1.2µA, MAX6069AB	T_A = -40°C to +85°C			50	
			T_A = -40°C to +125°C			75	
Long-Term Drift		1000h at T_A = +25°C			150		ppm
Thermal Hysteresis (Note 4)					200		ppm
MAX6069B (2.048V)							
Reverse Breakdown Voltage	V_R	T_A = +25°C, I_R = 1.2µA	MAX6069BA (0.2%)	2.0439	2.048	2.0521	V
			MAX6069BB (0.5%)	2.0378	2.048	2.0582	
Minimum Operating Current	I_{RMIN}	V_R change < 0.2% from V_R at I_R = 1.2µA			0.5	1.0	µA
Reverse Breakdown Change with Current		I_R = 1.2µA to 200µA				1.3	mV
		I_R = 200µA to 2mA				2.3	
Reverse Dynamic Impedance		I_R = 1.2µA to 2mA (Note 2)				1.8	Ω
Low-Frequency Noise		I_R = 1.2µA, f = 0.1Hz to 10Hz			50		µVp-p
Temperature Coefficient (Note 3)	TC	I_R = 1.2µA, MAX6069BA	T_A = -40°C to +85°C			20	ppm/°C
Temperature Coefficient (Note 3)			T_A = -40°C to +125°C			25	ppm/°C
Temperature Coefficient (Note 3)		I_R = 1.2µA, MAX6069BB	T_A = -40°C to +85°C			50	ppm/°C
Temperature Coefficient (Note 3)			T_A = -40°C to +125°C			75	ppm/°C
Long-Term Drift		1000h at T_A = +25°C			150		ppm
Thermal Hysteresis (Note 4)					200		ppm
MAX6069C (2.500V)							
Reverse Breakdown Voltage	V_R	T_A = +25°C, I_R = 1.2µA	MAX6069CA (0.2%)	2.4950	2.5000	2.5050	V
			MAX6069CB (0.5%)	2.4875	2.5000	2.5125	
Minimum Operating Current	I_{RMIN}	V_R change < 0.2% from V_R at I_R = 1.2µA			0.5	1.0	µA
Reverse Breakdown Change with Current		I_R = 1.2µA to 200µA				1.5	mV
		I_R = 200µA to 2mA				2.5	
Reverse Dynamic Impedance		I_R = 1.2µA to 2mA (Note 2)				2	Ω

Electrical Characteristics (continued)

(T_A=-40°C to +125°C, unless otherwise noted., Typical values are at T_A = +25°C. (Note 1))

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Low-Frequency Noise		I_R = 1.2µA, f = 0.1Hz to 10Hz			60		µVp-p
Temperature Coefficient (Note 3)	TC	I_R = 1.2µA, MAX6069CA	T_A = -40°C to +85°C			20	ppm/°C
			T_A = -40°C to +125°C			25	
		I_R = 1.2µA, MAX6069CB	T_A = -40°C to +85°C			50	
			T_A = -40°C to +125°C			75	
Long-Term Drift		1000h at T_A = +25°C			150		ppm
Thermal Hysteresis (Note 4)					200		ppm
MAX6069D (3.00V)							
Reverse Breakdown Voltage	V_R	T_A = +25°C, I_R = 1.2µA	MAX6069DA (0.2%)	2.9940	3.0000	3.0060	V
			MAX6069DB (0.5%)	2.9850	3.0000	3.0150	
Minimum Operating Current	I_{RMIN}	V_R change < 0.2% from V_R at I_R = 1.2µA			0.5	1.0	µA
Reverse Breakdown Change with Current		I_R = 1.2µA to 200µA				1.7	mV
		I_R = 200µA to 2mA				2.7	
Reverse Dynamic Impedance		I_R = 1.2µA to 2mA (Note 2)				2.2	Ω
Low-Frequency Noise		I_R = 1.2µA, f = 0.1Hz to 10Hz			75		µVp-p
Temperature Coefficient (Note 3)	TC	I_R = 1.2µA, MAX6069DA	T_A = -40°C to +85°C			20	ppm/°C
			T_A = -40°C to +125°C			25	
		I_R = 1.2µA, MAX6069DB	T_A = -40°C to +85°C			50	
			T_A = -40°C to +125°C			75	
Long-Term Drift		1000h at T_A = +25°C			150		ppm
Thermal Hysteresis (Note 4)					200		ppm

Note 1: All units are 100% production tested at T_A = +25°C and are guaranteed by design and characterization for T_A = T_{MIN} to T_{MAX}, as specified.

Note 2: This parameter is guaranteed by the “reverse breakdown change with current” test.

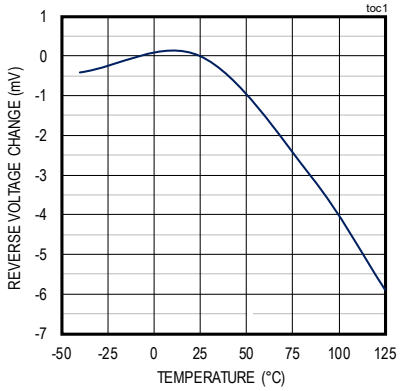
Note 3: TC is measured by the “box” method; i.e., (V_{MAX} - V_{MIN})/(T_{MAX} - T_{MIN}).

Note 4: Thermal hysteresis is defined as the change in the +25°C output voltage after cycling a unit from T_{MIN} to T_{MAX}.

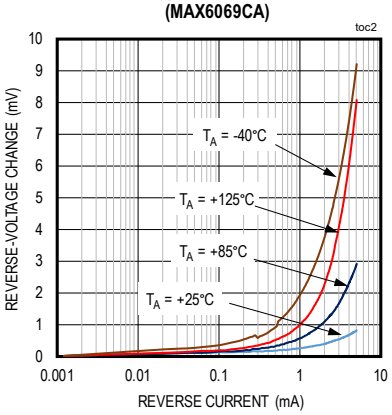
Typical Operating Characteristics

(T_A = +25°C, unless otherwise noted.)

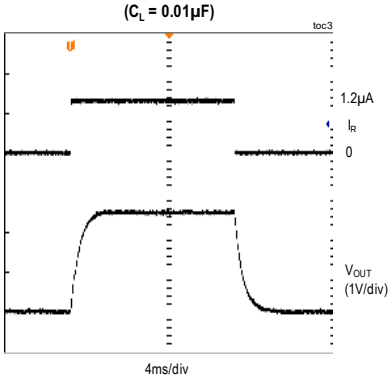
TEMPERATURE DRIFT (MAX6069CA)



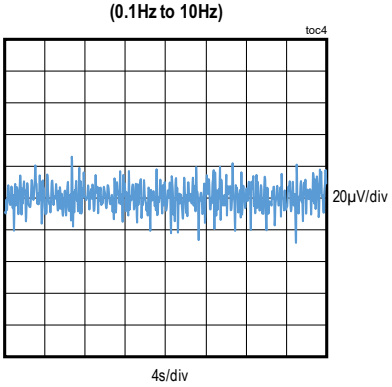
V_{OUT} vs. CURRENT (MAX6069CA)



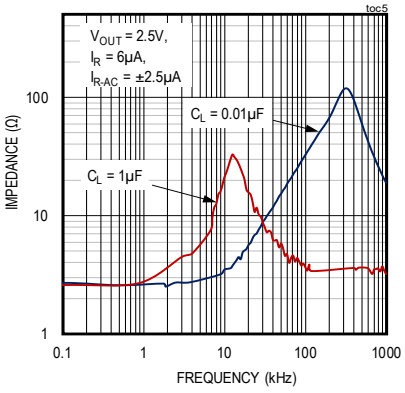
MAX6069CA STARTUP (C_L = 0.01µF)



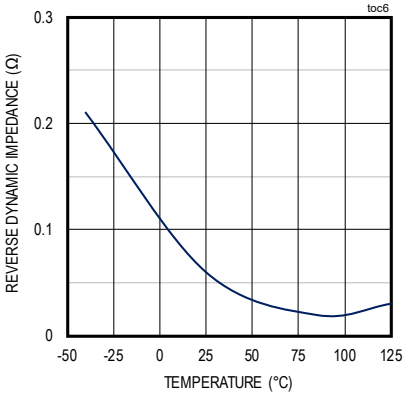
MAX6069CA PEAK-PEAK OUTPUT VOLTAGE NOISE (0.1Hz to 10Hz)



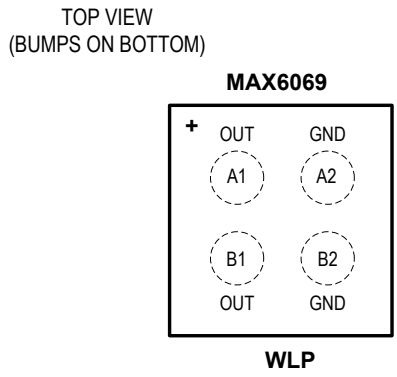
MAX6069CA OUTPUT IMPEDANCE vs. FREQUENCY



REVERSE DYNAMIC IMPEDANCE vs. TEMPERATURE (MAX6069CA)



Pin Configuration



Pin Description

PIN	NAME	FUNCTION
A1	OUT	Output Voltage. Bias OUT with a pullup resistor to a potential greater than OUT. Bypass OUT to GND with a 0.01µF or larger capacitor.
A2	GND	Ground
B1	OUT	Output Voltage. B1 is shorted to A1 internally.
B2	GND	Ground. B2 is shorted to A2 internally.

Detailed Description

The MAX6069 family consists of precision, two-terminal, shunt bandgap voltage references. On-chip, thin-film resistors are laser-trimmed to provide 0.2% output voltage accuracies. Voltages of +1.25V, +2.048V, +2.5V, and +3.0V are available in a space-saving 4-bump WLP.

Applications Information

Output/Load Capacitance

Bypass OUT to GND with a 0.01µF or larger capacitor. In applications where the load or the supply can experience step changes, additional capacitance will reduce the amount of overshoot (or undershoot) and assist the circuit's transient response.

Output Voltage Hysteresis

Output voltage hysteresis is the change in the output voltage at T_A = +25°C before and after the device is cycled over its entire operating temperature range. Hysteresis is caused by differential package stress appearing across the bandgap core transistors. The temperature hysteresis value is typically less than 200ppm.

Turn-On Time

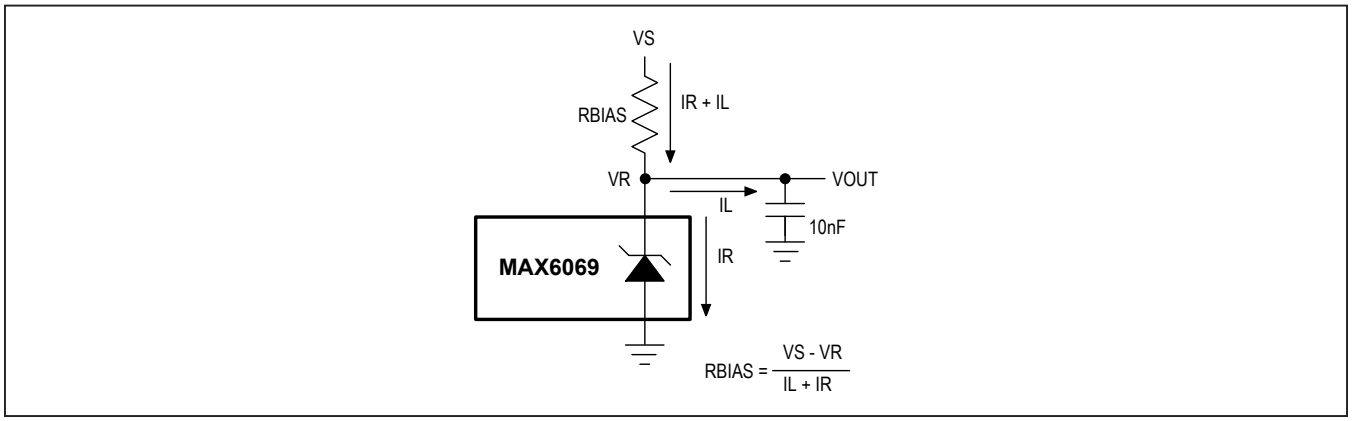
The output capacitance and bias current of the MAX6069 greatly affect turn-on settling time. In the *Typical Operating Characteristics*, turn-on time is shown with a 10nF output capacitor and a 1.2µA bias current. Under these conditions, the MAX6069 settles in about 4ms. Settling time linearly decreases in proportion to the circuit's bias current.

Typical Application Circuits

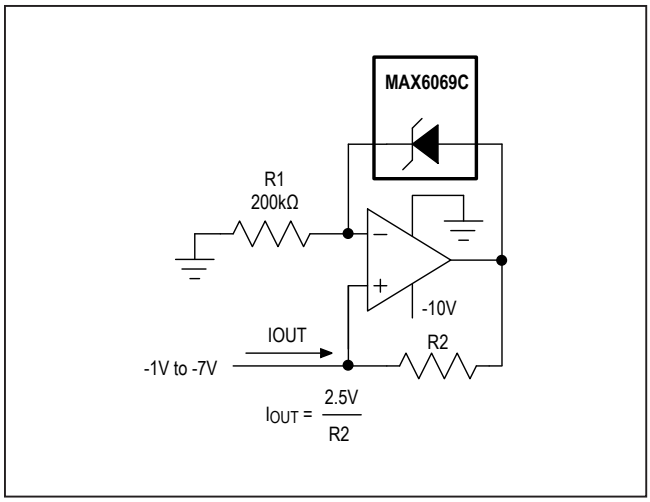
Shunt Regulator Connection

In the typical shunt regulator connection shown here, R_{BIAS} sets the current through the load (I_L) and the current through the shunt regulator(I_R). There are two worst-case situations that R_{BIAS} needs to be sized for:

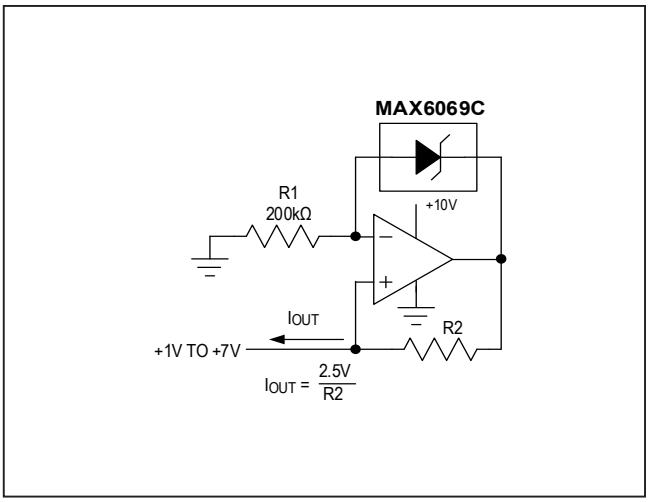
1) R_{BIAS} must be small enough that when V_S (supply voltage) is at its minimum and I_L is at its maximum, I_R is equal to at least the minimum operating current of the shunt regulator.
2) R_{BIAS} must be large enough that when V_S is at its maximum and I_L is at its minimum, I_R is < 2mA.



Precision Current Sink



Precision Current Source



Ordering Information

PART NUMBER	OUTPUT VOLTAGE (V)	INITIAL ACCURACY (%)	TEMP COEFFICIENT (PPM/°C)	PIN-PACKAGE	TOP MARK
MAX6069AAAWS+*	1.250	0.2	20	4 WLP	+AM
MAX6069AAAWS+T*	1.250	0.2	20	4 WLP	+AM
MAX6069ABAWS+*	1.250	0.5	50	4 WLP	+AN
MAX6069ABAWS+T*	1.250	0.5	50	4 WLP	+AN
MAX6069BAAWS+	2.048	0.2	20	4 WLP	+AO
MAX6069BAAWS+T	2.048	0.2	20	4 WLP	+AO
MAX6069BBAWS+*	2.048	0.5	50	4 WLP	+AP
MAX6069BBAWS+T*	2.048	0.5	50	4 WLP	+AP
MAX6069CAAWS+	2.500	0.2	20	4 WLP	+AQ
MAX6069CAAWS+T	2.500	0.2	20	4 WLP	+AQ
MAX6069CBAWS+	2.500	0.5	50	4 WLP	+AR
MAX6069CBAWS+T	2.500	0.5	50	4 WLP	+AR
MAX6069DAAWS+*	3.000	0.2	20	4 WLP	+AS
MAX6069DAAWS+T*	3.000	0.2	20	4 WLP	+AS
MAX6069DBAWS+*	3.000	0.5	50	4 WLP	+AT
MAX6069DBAWS+T*	3.000	0.5	50	4 WLP	+AT

+Denotes a lead(Pb)-free/RoHS-compliant package.
T = Tape and reel.
**Future product—contact factory for availability.*

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	6/17	Initial release	—
1	10/21	Updated *Electrical Characteristics, Precision Current Source* figure, and *Ordering Information*	3, 4, 7, 8

Information furnished by Analog Devices is believed to be accurate and reliable. However, no responsibility is assumed by Analog Devices for its use, nor for any infringements of patents or other rights of third parties that may result from its use.Specifications subject to change without notice. No license is granted by implicationor otherwise under any patent or patent rights of Analog Devices. Trademarks andregistered trademarks are the property of their respective owners.