19-1730; Rev 0; 8/00

1µA SOT23 Precision Shunt Voltage Reference

MAX6006–MAX6009

General Description

The MAX6006–MAX6009 ultra-low-power shunt references are ideal for space-critical and low-power applications. They are offered in 3-pin SOT23 packages, and the minimum operating current is guaranteed to be <1µA. The devices feature low temperature coefficients of <30ppm/°C and initial accuracy of better than 0.2%.

Available in +1.25V, +2.048V, +2.5V, and 3V output voltages, the MAX6006–MAX6009 have references of +1.25V, +2.048V, +2.5V, and +3.0V, respectively. The devices can be used as lower-power, higher-precision upgrades to the ICL8069, LM385, LT1004, and LM4040 references. The MAX6006–MAX6009 are available in two grades: A and B. The A grade features a temperature coefficient of 30ppm/°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 75ppm/°C with an initial accuracy of 0.5%. MAX6006 in+1.25V and MAX6008 in +2.5V are offered in 8-pin SOIC packages, as plug in upgrades for LT1004 and LM285.

Applications

Battery-Powered Equipment

Portable Meters

Precision Regulators

A/D and D/A Converters

Features

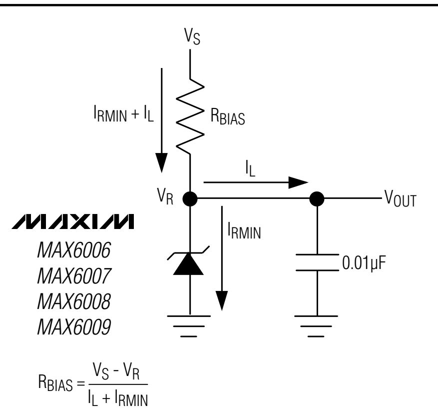
- ♦ **Ultra-Low Operating Current: Guaranteed <1µA**
- ♦ **Small 3-Pin SOT23 Package**
- ♦ **Initial Voltage Accuracy: 0.2%**
- ♦ **Temperature Coefficient: 30ppm/°C max**
- ♦ **Temperature Range: -40°C to +85°C**
- ♦ **Factory-Trimmed Output Voltages: +1.25V, +2.048V, +2.5V, +3.0V**
- ♦ **Wide Operating Range: 1µA to 2mA**

Selector Guide

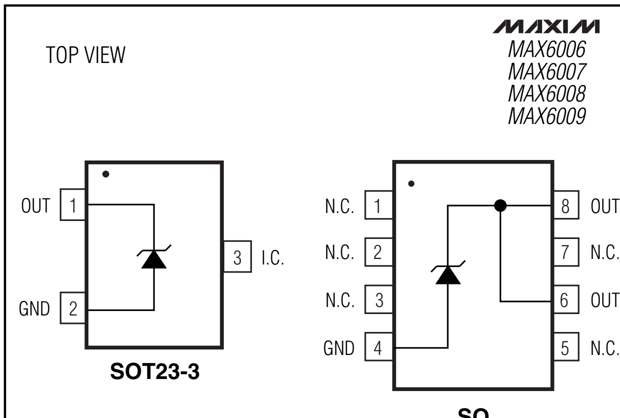
PART	OUTPUT VOLTAGE (V)	INITIAL ACCURACY (%)	TEMPERATURE COEFFICIENT (ppm/°C)
MAX6006A	1.25	0.2	30
MAX6006B	1.25	0.5	75
MAX6007A	2.048	0.2	30
MAX6007B	2.048	0.5	75
MAX6008A	2.5	0.2	30
MAX6008B	2.5	0.5	75
MAX6009A	3.0	0.2	30
MAX6009B	3.0	0.5	75

Ordering Information appears at end of data sheet

Typical Operating Circuit



Pin Configuration



ABSOLUTE MAXIMUM RATINGS

Operating Current (OUT to GND) 20mA
Forward Current (GND to OUT) 20mA
Continuous Power Dissipation (T_A = +70°C)
3-Pin SOT23 (derate 4mW/°C above +70°C).............320mW
8-Pin SO (derate 5.48mW/°C above +70°C)..............471mW
Operating Temperature Range ....-40°C to +85°C
Storage Temperature Range ....-65°C to +150°C
Lead Temperature (soldering, 10s) ....+300°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.

ELECTRICAL CHARACTERISTICS—MAX6006

(T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Reverse Breakdown Voltage	V_R	T_A = +25°C, I_R = 1.2µA	MAX6006A (0.2%)	1.2475	1.2500	1.2525	V
			MAX6006B (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				1.0	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		$µV_{p-p}$
Temperature Coefficient (Note 3)	TC	I_R = 1.2µA	MAX6006A			30	ppm/°C
			MAX6006B			75	
Long-Term Drift		1000h at T_A = +25°C			150		ppm
Thermal Hysteresis (Note 4)					200		ppm

ELECTRICAL CHARACTERISTICS—MAX6007

(T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Reverse Breakdown Voltage	V_R	T_A = +25°C, I_R = 1.2µA	MAX6007A (0.2%)	2.0439	2.048	2.0521	V
			MAX6007B (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		μV_{p-p}
Temperature Coefficient (Note 3)	TC	I_R = 1.2µA	MAX6007A			30	ppm/°C
			MAX6007B			75	
Long-Term Drift		1000h at T_A = +25°C			150		ppm
Thermal Hysteresis (Note 4)					200		ppm

ELECTRICAL CHARACTERISTICS—MAX6008

(T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Reverse Breakdown Voltage	V_R	T_A = +25∘C, I_R = 1.2µA	MAX6008A (0.2%)	2.4950	2.5000	2.5050	V
			MAX6008B (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
Low-Frequency Noise		I_R = 1.2µA, f = 0.1Hz to 10Hz			60		μV_{p-p}
Temperature Coefficient (Note 3)	TC	I_R = 1.2µA	MAX6008A			30	ppm/∘C
			MAX6008B			75	
Long-Term Drift		1000h at T_A = +25°C			150		ppm
Thermal Hysteresis (Note 4)					200		ppm

1µA SOT23 Precision Shunt Voltage Reference

ELECTRICAL CHARACTERISTICS—MAX6009

(T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

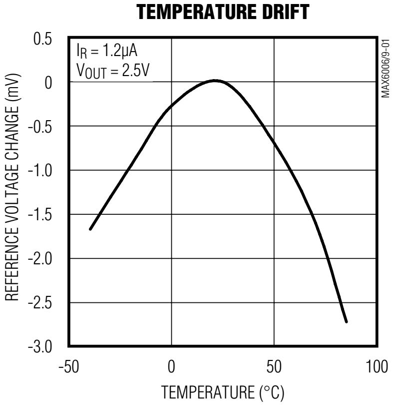
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Reverse Breakdown Voltage	V_R	T_A = +25°C, I_R = 1.2µA	MAX6009A (0.2%)	2.9940	3.000	3.0060	V
			MAX6009B (0.5%)	2.9850	3.000	3.0150	
Minimum Operating Current	I_{RMIN}	V_R change <0.2% from V_R at I_R = 1.2µA			0.5	1.0	µA
Reverse Breakdown Change with Current		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		$µV_{p-p}$
Temperature Coefficient (Note 3)	TC	I_R = 1.2µA	MAX6009A			30	ppm/°C
			MAX6009B			75	
Long-Term Drift		1000h at T_A = +25°C			150		ppm
Thermal Hysteresis (Note 4)					200		ppm

Note 1: All devices are 100% production tested at T_A = +25°C and are guaranteed by design 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 the device from T_{MIN} to T_{MAX} .

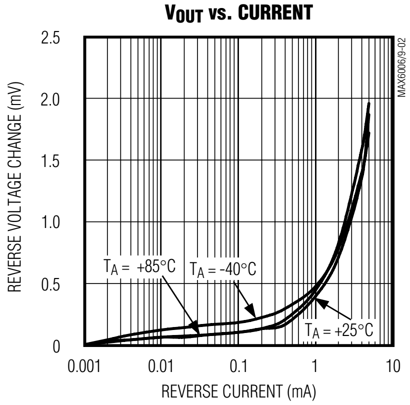
Typical Operating Characteristics

(C_L = 0.01µF, T_A = +25°C, unless otherwise noted.)

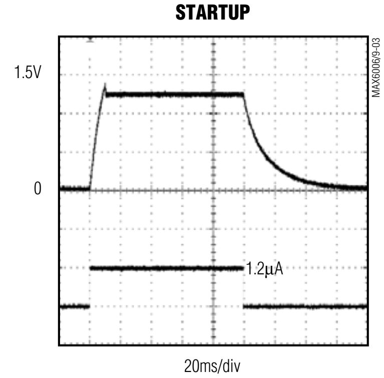
TEMPERATURE DRIFT



MAX6006
VOUT vs. CURRENT



MAX6006
STARTUP

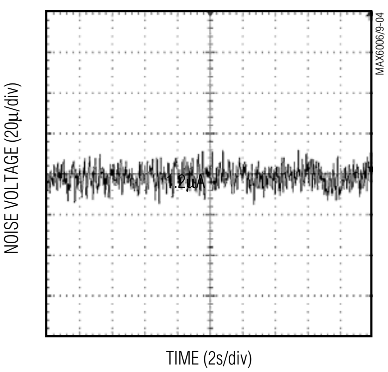


MAXIM

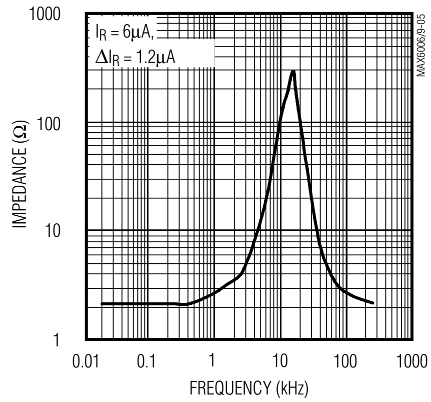
Typical Operating Characteristics (continued)

(C_L = 0.01µF, T_A = +25°C, unless otherwise noted.)

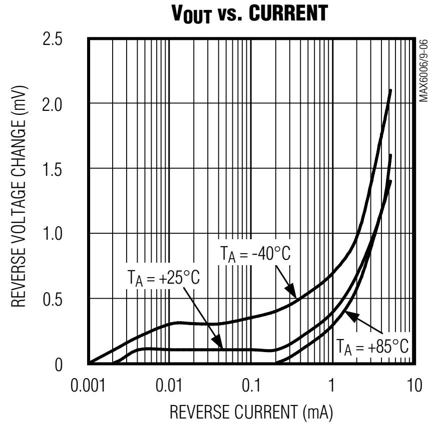
MAX6006
0.01Hz TO 10Hz NOISE



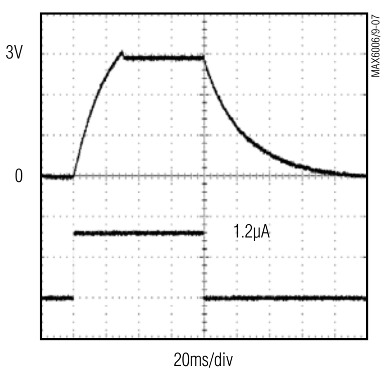
MAX6006
OUTPUT IMPEDANCE vs. FREQUENCY



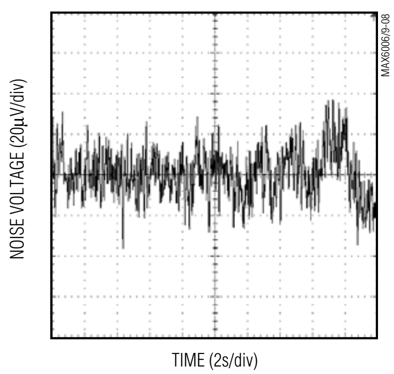
MAX6009
V_{OUT} vs. CURRENT



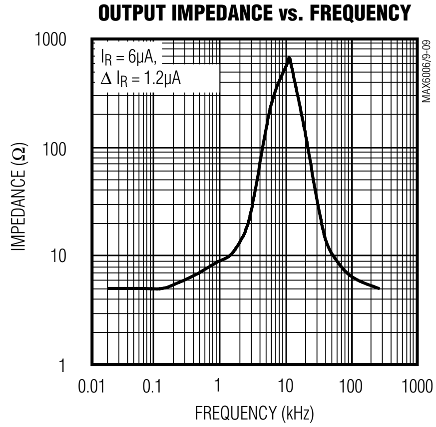
MAX6009
STARTUP



MAX6009
0.01Hz TO 10Hz NOISE



MAX6009
OUTPUT IMPEDANCE vs. FREQUENCY



1µA SOT23 Precision Shunt Voltage Reference

Pin Description

PIN		NAME	FUNCTION
SOT23	SO		
1	6, 8	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.
2	4	GND	Ground
3	—	IC	Internally connected test point. Leave this pin unconnected, or connect to GND.
—	1, 2, 3, 5, 7	N.C.	No connection. Not internally connected.

Detailed Description

The MAX6006–MAX6009 are precision, two-terminal, series 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 the space-saving SOT23 package (2.1mm × 2.7mm).

Applications Information

Output/Load Capacitance

For devices in this family, OUT needs to be bypassed 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 MAX6006–MAX6009 greatly affects 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 MAX6006–MAX6009 settle in 40ms. Settling time will linearly decrease in proportion to the circuit's bias current.

Typical Applications

In the typical shunt regulator application shown in Figure 1, R_{BIAS} is used to set the current through the load (I_L) and the current through the shunt regulator (I_{RMIN}). 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_{RMIN} 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_{RMIN} is <2mA.

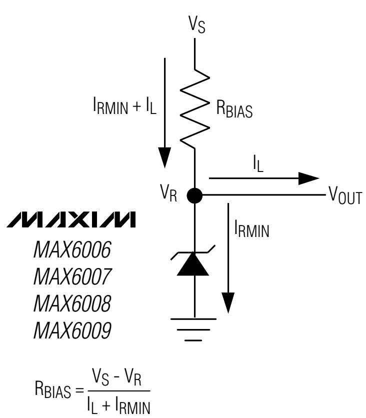


Figure 1. Typical Application Circuit

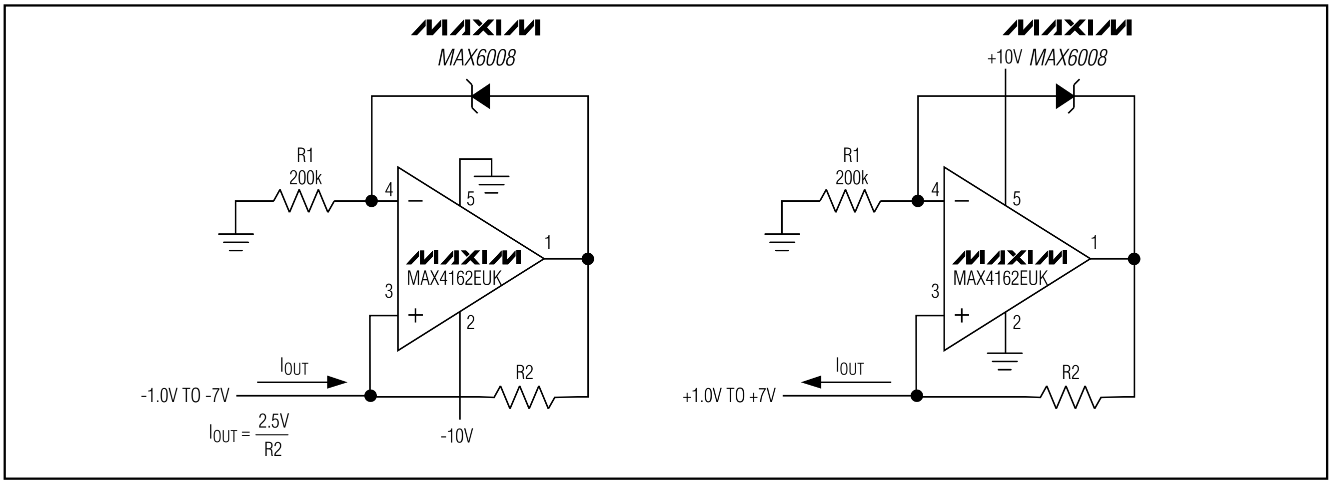


Figure 2. Precision 1µA to 1mA Current Sources

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE	TOP MARK
MAX6006AEUR-T	-40°C to +85°C	3 SOT23	FZGH
MAX6006AESA	-40°C to +85°C	8 SO	—
MAX6006BEUR-T	-40°C to +85°C	3 SOT23	FZGI
MAX6006BESA	-40°C to +85°C	8 SO	—
MAX6007AEUR-T	-40°C to +85°C	3 SOT23	FZGK
MAX6007BEUR-T	-40°C to +85°C	3 SOT23	FZGL
MAX6008AEUR-T	-40°C to +85°C	3 SOT23	FZGN
MAX6008AESA	-40°C to +85°C	8 SO	—
MAX6008BEUR-T	-40°C to +85°C	3 SOT23	FZGO
MAX6008BESA	-40°C to +85°C	8 SO	—
MAX6009AEUR-T	-40°C to +85°C	3 SOT23	FZGQ
MAX6009BEUR-T	-40°C to +85°C	3 SOT23	FZGR

Chip Information

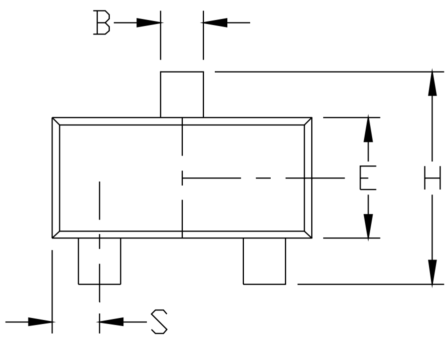
TRANSISTOR COUNT: 60
PROCESS: BiCMOS

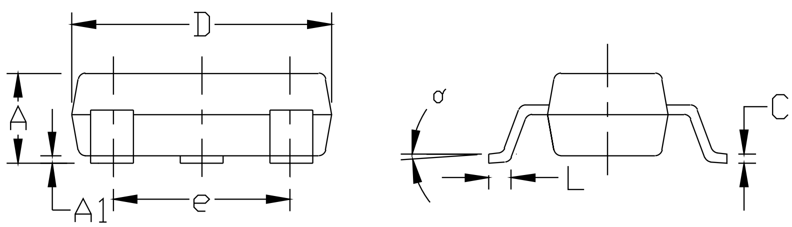
Package Information

SOTPO3L.EPS

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. CONTROLLING DIMENSION: MILLIMETER

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.031	0.047	0.787	1.194
A1	0.001	0.005	0.025	0.127
B	0.014	0.022	0.356	0.559
C	0.0034	0.006	0.086	0.152
D	0.105	0.120	2.667	3.048
E	0.047	0.055	1.194	1.397
e	0.070	0.080	1.778	2.032
H	0.082	0.098	2.083	2.489
L	0.004	0.012	0.102	0.305
S	0.017	0.022	0.432	0.559
α	0°	8°	0°	8°





PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE,SOT-23, 3L

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