MAX6173–MAX6177

High-Precision Voltage References with Temperature Sensor

General Description

The MAX6173–MAX6177 are low-noise, high-precision voltage references. The devices feature a proprietary temperature-coefficient curvature-correction circuit and laser-trimmed thin-film resistors that result in a very low 3ppm/°C temperature coefficient and excellent ±0.06% initial accuracy. The MAX6173–MAX6177 provide a TEMP output where the output voltage is proportional to the die temperature, making the devices suitable for a wide variety of temperature-sensing applications. The devices also provide a TRIM input, allowing fine trimming of the output voltage with a resistive divider network. Low temperature drift and low noise make the devices ideal for use with high-resolution A/D or D/A converters.

The MAX6173–MAX6177 provide accurate preset +2.5V, +3.3V, +4.096V, +5.0V, and +10V reference voltages and accept input voltages up to +40V. The devices draw 320µA (typ) of supply current and source 30mA or sink 2mA of load current. The MAX6173–MAX6177 use bandgap technology for low-noise performance and excellent accuracy. The MAX6173–MAX6177 do not require an output bypass capacitor for stability, and are stable with capacitive loads up to 100µF. Eliminating the output bypass capacitor saves valuable board area in space-critical applications.

The MAX6173–MAX6177 are available in an 8-pin SO package and operate over the automotive (-40°C to +125°C) temperature range.

Applications

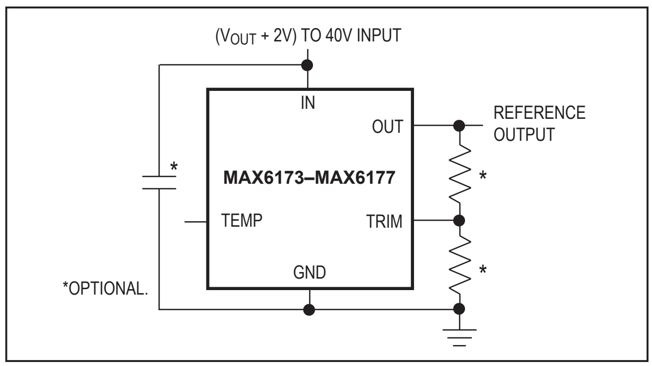
- ADCs
- DACs
- Digital Voltmeters
- Automotive
- Voltage Regulators
- Threshold Detectors

Pin Configuration and Ordering Information appears at end of data sheet.

Benefits and Features

- Wide (V_{OUT} + 2V) to +40V Supply Voltage Range
- Excellent Temperature Stability: 3ppm/°C (max)
- Tight Initial Accuracy: 0.05% (max)
- Low Noise: 3.8µV_{P-P} (typ at 2.5V Output)
- Sources up to 30mA Output Current
- Low Supply Current: 450µA (max at +25°C)
- Linear Temperature Transducer Voltage Output
- +2.5V, +3.3V, +4.096V, +5.0V, or +10V Output Voltages
- Wide Operating Temperature Range: -40°C to +125°C
- No External Capacitors Required for Stability
- Short-Circuit Protected
- AEC-Q100 Qualified (Refer to Ordering Info Section for /V parts)

Typical Operating Circuit



Absolute Maximum Ratings

IN to GND..-0.3V to +42V
OUT, TRIM, TEMP to GND ....-0.3V to (V_{IN} + 0.3V)
Output Short-Circuit to GND 5s
Continuous Power Dissipation (T_A = +70°C) (Note1)
8-Pin SO (derate 7.6mW/°C above +70°C)................606mW
Operating Temperature Range........................ -40°C to +125°C
Junction Temperature..+150°C
Storage Temperature Range........................... -65°C to +150°C
Lead Temperature (soldering, 10s) ....+300°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 Thermal Characteristics (Note 1)

8 SO

PACKAGE CODE	S8+4
Outline Number	**21-0041**
Land Pattern Number	**90-0096**
Thermal Resistance, Single-Layer Board	
Junction to Ambient - θ_{JA}	170
Junction to Case - θ_{JC}	40
Thermal Resistance, Multi-Layer Board	
Junction to Ambient - θ_{JA}	132°C/W
Junction to Case - θ_{JC}	38°C/W

8 SO

PACKAGE CODE	S8+22
Outline Number	**21-0041**
Land Pattern Number	**90-0096**
Thermal Resistance, Single-Layer Board	
Junction to Ambient - θ_{JA}	170°C/W
Junction to Case - θ_{JC}	40°C/W
Thermal Resistance, Multi-Layer Board	
Junction to Ambient - θ_{JA}	132°C/W
Junction to Case - θ_{JC}	38°C/W

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—MAX6173 (V_{OUT} = 2.5V)

(V_{IN} = +5V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
OUTPUT							
Output Voltage	V_{OUT}	No load, T_A = +25°C	MAX6173A (0.06%)	2.4985	2.5	2.5015	V
			MAX6173B (0.1%)	2.4975	2.5	2.5025	
Output Adjustment Range	ΔV_{TRIM}	R_{POT} = 10kΩ		±3	±6		%
Output-Voltage Temperature Coefficient (Note 3)	TCV_{OUT}	T_A = -40°C to +125°C	MAX6173AASA		1.5	3	ppm/°C
			MAX6173BASA		3	10	
Line Regulation (Note 4)	$\Delta V_{OUT}/\Delta V_{IN}$	4.5V ≤ V_{IN} ≤ 40V	T_A = +25°C		0.6	5	ppm/V
			T_A = -40°C to +125°C		0.8	10	
Load Regulation (Note 4)	$\Delta V_{OUT}/\Delta I_{OUT}$	Sourcing: 0 ≤ I_{OUT} ≤ 10mA	T_A = +25°C		2	10	ppm/mA
			T_A = -40°C to +125°C		2	15	
		Sinking: -0.6mA ≤ I_{OUT} ≤ 0	T_A = +25°C		50	500	
			T_A = -40°C to +125°C		90	900	
Output Short-Circuit Current	I_{SC}	OUT shorted to GND			60		mA
		OUT shorted to IN			3		
Temperature Hysteresis (Note 5)	ΔV_{OUT}/ cycle				120		ppm
Long-Term Stability	ΔV_{OUT}/ time	1000 hours at T_A = +25°C			50		ppm
DYNAMIC							
Noise Voltage	e_{OUT}	f = 0.1Hz to 10Hz			3.8		μV_{P-P}
		f = 10Hz to 1kHz			6.8		μV_{RMS}
Turn-On Settling Time	t_R	To V_{OUT} = 0.1% of final value, C_{OUT} = 50pF			150		µs
INPUT							
Supply Voltage Range	V_{IN}	Guaranteed by line regulation test		4.5		40.0	V
Quiescent Supply Current	I_{IN}	No load	T_A = +25°C		300	450	µA
			T_A = -40°C to +125°C			600	
TEMP OUTPUT							
TEMP Output Voltage	V_{TEMP}				570		mV
TEMP Temperature Coefficient	TC_{TEMP}				1.9		mV/°C

Electrical Characteristics—MAX6177 (V_{OUT} = 3.3V)

(V_{IN} = +10V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
OUTPUT							
Output Voltage	V_{OUT}	No load, T_A = +25°C	MAX6177A (0.06%)	3.2980	3.3	3.3020	V
			MAX6177B (0.1%)	3.2967	3.3	3.3033	
Output Adjustment Range	ΔV_{TRIM}	R_{POT} = 10kΩ		±3	±6		%
Output-Voltage Temperature Coefficient (Note 3)	TCV_{OUT}	T_A = -40°C to +125°C	MAX6177AASA		1.5	3	ppm/°C
			MAX6177BASA		3	10	
Line Regulation (Note 4)	$\Delta V_{OUT}/\Delta V_{IN}$	5.3V ≤ V_{IN} ≤ 40V	T_A = +25°C		0.6	5	ppm/V
			T_A = -40°C to +125°C		0.8	10	
Load Regulation (Note 4)	$\Delta V_{OUT}/\Delta I_{OUT}$	Sourcing: 0 ≤ I_{OUT} ≤ 10mA	T_A = +25°C		2	10	ppm/mA
			T_A = -40°C to +125°C		2	15	
		Sinking: -0.6mA ≤ I_{OUT} ≤ 0	T_A = +25°C		50	500	
			T_A = -40°C to +125°C		90	900	
Output Short-Circuit Current	I_{SC}	OUT shorted to GND			60		mA
		OUT shorted to IN			3		
Temperature Hysteresis (Note 5)	ΔV_{OUT}/cycle				120		ppm
Long-Term Stability	ΔV_{OUT}/time	1000 hours at T_A = +25°C			50		ppm
DYNAMIC							
Noise Voltage	e_{OUT}	f = 0.1Hz to 10Hz			5		μV_{P-P}
		f = 10Hz to 1kHz			9.3		μV_{RMS}
Turn-On Settling Time	t_R	To V_{OUT} = 0.1% of final value, C_{OUT} = 50pF			180		µs
INPUT							
Supply Voltage Range	V_{IN}	Guaranteed by line regulation test		5.3		40.0	V
Quiescent Supply Current	I_{IN}	No load	T_A = +25°C		320	500	µA
			T_A = -40°C to +125°C			650	
TEMP OUTPUT							
TEMP Output Voltage	V_{TEMP}				630		mV
TEMP Temperature Coefficient	TC_{TEMP}				2.1		mV/°C

Electrical Characteristics—MAX6174 (V_{OUT} = 4.096V)

(V_{IN} = +10V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
OUTPUT							
Output Voltage	V_{OUT}	No load, T_A = +25°C	MAX6174A (0.06%)	4.0935	4.096	4.0985	V
			MAX6174B (0.1%)	4.0919	4.096	4.1001	
Output Adjustment Range	ΔV_{TRIM}	R_{POT} = 10kΩ		±3	±6		%
Output-Voltage Temperature Coefficient (Note 3)	TCV_{OUT}	T_A = -40°C to +125°C	MAX6174AASA		1.5	3	ppm/°C
			MAX6174BASA		3	10	
Line Regulation (Note 4)	$\Delta V_{OUT}/\Delta V_{IN}$	6.1V ≤ V_{IN} ≤ 40V	T_A = +25°C		0.6	5	ppm/V
			T_A = -40°C to +125°C		0.8	10	
Load Regulation (Note 4)	$\Delta V_{OUT}/\Delta I_{OUT}$	Sourcing: 0 ≤ I_{OUT} ≤ 10mA	T_A = +25°C		2	10	ppm/mA
			T_A = -40°C to +125°C		2	15	
		Sinking: -0.6mA ≤ I_{OUT} ≤ 0	T_A = +25°C		50	500	
			T_A = -40°C to +125°C		90	900	
Output Short-Circuit Current	I_{SC}	OUT shorted to GND			60		mA
		OUT shorted to IN			3		
Temperature Hysteresis (Note 5)	ΔV_{OUT}/cycle				120		ppm
Long-Term Stability	ΔV_{OUT}/time	1000 hours at T_A = +25°C			50		ppm
DYNAMIC							
Noise Voltage	e_{OUT}	f = 0.1Hz to 10Hz			7		μV_{P-P}
		f = 10Hz to 1kHz			11.5		μV_{RMS}
Turn-On Settling Time	t_R	To V_{OUT} = 0.1% of final value, C_{OUT} = 50pF			200		µs
INPUT							
Supply Voltage Range	V_{IN}	Guaranteed by line regulation test		6.1		40.0	V
Quiescent Supply Current	I_{IN}	No load	T_A = +25°C		320	500	µA
			T_A = -40°C to +125°C			650	
TEMP OUTPUT							
TEMP Output Voltage	V_{TEMP}	T_A = +25°C		475	630	785	mV
		T_A = -40°C to +125°C		300		1130	
TEMP Temperature Coefficient	TC_{TEMP}				2.1		mV/°C

Electrical Characteristics—MAX6175 (V_{OUT} = 5.0V)

(V_{IN} = +15V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
OUTPUT							
Output Voltage	V_{OUT}	No load, T_A = +25°C	MAX6175A (0.06%)	4.9970	5.0	5.0030	V
			MAX6175B (0.1%)	4.9950	5.0	5.0050	
Output Adjustment Range	ΔV_{TRIM}	R_{POT} = 10kΩ		±3	±6		%
Output-Voltage Temperature Coefficient (Note 3)	TCV_{OUT}	T_A = -40°C to +125°C	MAX6175AASA		1.5	3	ppm/°C
			MAX6175BASA		3	10	
Line Regulation (Note 4)	$\Delta V_{OUT}/\Delta V_{IN}$	7V ≤ V_{IN} ≤ 40V	T_A = +25°C		0.6	5	ppm/V
			T_A = -40°C to +125°C		0.8	10	
Load Regulation (Note 4)	$\Delta V_{OUT}/\Delta I_{OUT}$	Sourcing: 0 ≤ I_{OUT} ≤ 10mA	T_A = +25°C		2	10	ppm/mA
			T_A = -40°C to +125°C		2	15	
		Sinking: -0.6mA ≤ I_{OUT} ≤ 0	T_A = +25°C		50	500	
			T_A = -40°C to +125°C		90	900	
Output Short-Circuit Current	I_{SC}	OUT shorted to GND			60		mA
		OUT shorted to IN			3		
Temperature Hysteresis (Note 5)	ΔV_{OUT}/cycle				120		ppm
Long-Term Stability	ΔV_{OUT}/time	1000 hours at T_A = +25°C			50		ppm
DYNAMIC							
Noise Voltage	e_{OUT}	f = 0.1Hz to 10Hz			9		μV_{P-P}
		f = 10Hz to 1kHz			14.5		μV_{RMS}
Turn-On Settling Time	t_R	To V_{OUT} = 0.1% of final value, C_{OUT} = 50pF			230		µs
INPUT							
Supply Voltage Range	V_{IN}	Guaranteed by line regulation test		7.0		40.0	V
Quiescent Supply Current	I_{IN}	No load	T_A = +25°C		320	550	µA
			T_A = -40°C to +125°C			700	
TEMP OUTPUT							
TEMP Output Voltage	V_{TEMP}	T_A = +25°C		475	630	785	mV
		T_A = -40°C to +125°C		300		1130	
TEMP Temperature Coefficient	TC_{TEMP}				2.1		mV/°C

ELECTRICAL CHARACTERISTICS—MAX6176 (V_{OUT} = 10V)

(V_{IN} = +15V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

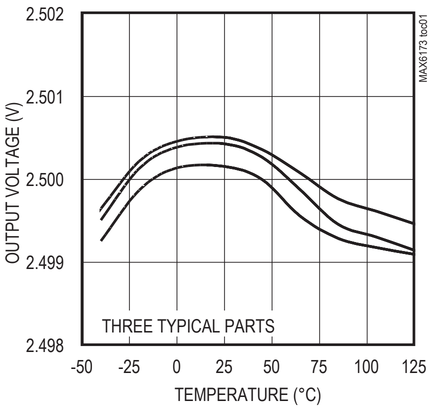
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
OUTPUT							
Output Voltage	V_{OUT}	No load, T_A = +25°C	MAX6176A (0.05%)	9.9950	10.0	10.0050	V
			MAX6176B (0.1%)	9.9900	10.0	10.0100	
Output Adjustment Range	ΔV_{TRIM}	R_{POT} = 10kΩ		±3	±6		%
Output-Voltage Temperature Coefficient (Note 3)	TCV_{OUT}	T_A = -40°C to +125°C	MAX6176AASA		1.5	3	ppm/°C
			MAX6176BASA		3	10	
Line Regulation (Note 4)	$\Delta V_{OUT}/\Delta V_{IN}$	12V ≤ V_{IN} ≤ 40V	T_A = +25°C		0.6	5	ppm/V
			T_A = -40°C to +125°C		0.8	10	
Load Regulation (Note 4)	$\Delta V_{OUT}/\Delta I_{OUT}$	Sourcing: 0 ≤ I_{OUT} ≤ 10mA	T_A = +25°C		2	10	ppm/mA
			T_A = -40°C to +125°C		2	15	
		Sinking: -0.6mA ≤ I_{OUT} ≤ 0	T_A = +25°C		50	500	
			T_A = -40°C to +125°C		90	900	
Output Short-Circuit Current	I_{SC}	OUT shorted to GND			60		mA
		OUT shorted to IN			3		
Temperature Hysteresis (Note 5)	ΔV_{OUT}/cycle				120		ppm
Long-Term Stability	ΔV_{OUT}/time	1000 hours at T_A = +25°C			50		ppm
DYNAMIC							
Noise Voltage	e_{OUT}	f = 0.1Hz to 10Hz			18		μV_{P-P}
		f = 10Hz to 1kHz			29		μV_{RMS}
Turn-On Settling Time	t_R	To V_{OUT} = 0.1% of final value, C_{OUT} = 50pF			400		µs
INPUT							
Supply Voltage Range	V_{IN}	Guaranteed by line regulation test		12.0		40.0	V
Quiescent Supply Current	I_{IN}	No load	T_A = +25°C		340	550	µA
			T_A = -40°C to +125°C			700	
TEMP OUTPUT							
TEMP Output Voltage	V_{TEMP}				630		mV
TEMP Temperature Coefficient	TC_{TEMP}				2.1		mV/°C

Note 2: All devices are 100% production tested at T_A = +25°C and guaranteed by design over T_A = T_{MIN} to T_{MAX}, as specified.
Note 3: Temperature coefficient is defined as ΔV_{OUT} divided by the temperature range.
Note 4: Line and load regulation specifications do not include the effects of self-heating.
Note 5: Thermal hysteresis is defined as the change in +25°C output voltage before and after cycling the device from T_{MAX} to T_{MIN}.

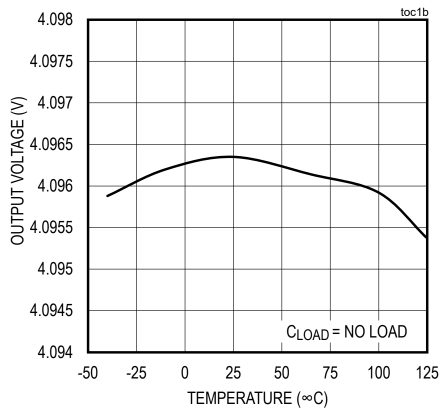
Typical Operating Characteristics

(V_{IN} = +5V for V_{OUT} = +2.5V, V_{IN} = +15V for V_{OUT} = 4.096V and V_{OUT} = +10V, I_{OUT} = 0, T_A = +25°C, unless otherwise noted.)

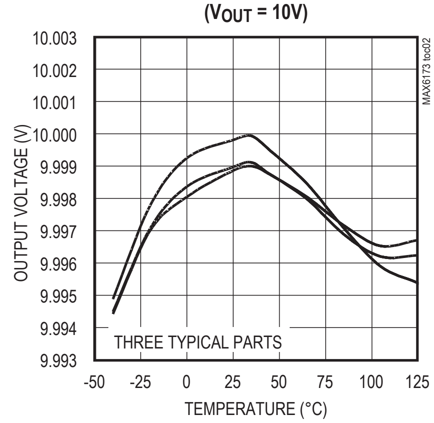
OUTPUT VOLTAGE vs. TEMPERATURE (V_{OUT} = 2.5V)



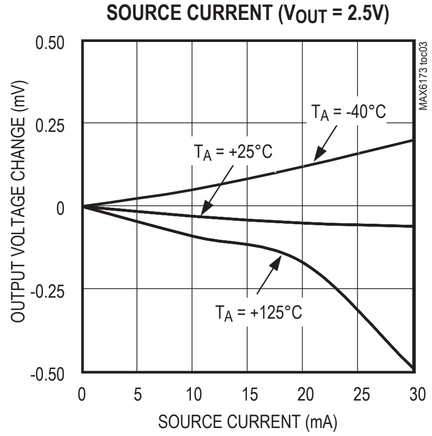
OUTPUT VOLTAGE vs. TEMPERATURE (V_{OUT} = 4.096V)



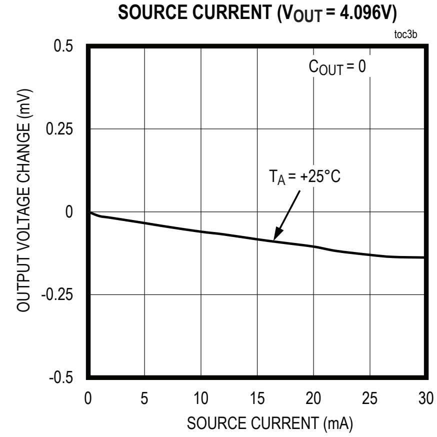
OUTPUT VOLTAGE vs. TEMPERATURE (V_{OUT} = 10V)



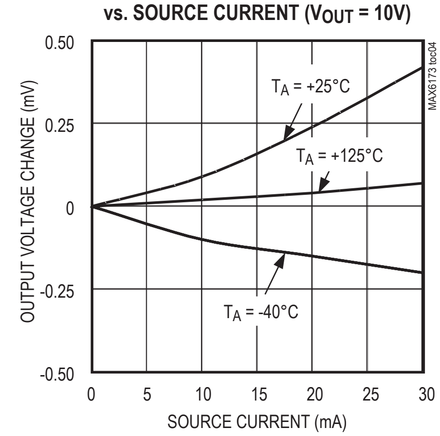
LOAD REGULATION vs. SOURCE CURRENT (V_{OUT} = 2.5V)



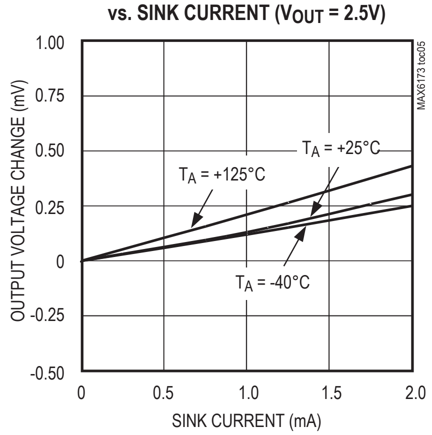
LOAD REGULATION vs. SOURCE CURRENT (V_{OUT} = 4.096V)



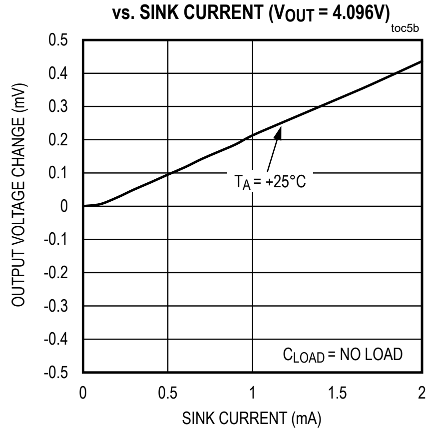
LOAD REGULATION vs. SOURCE CURRENT (V_{OUT} = 10V)



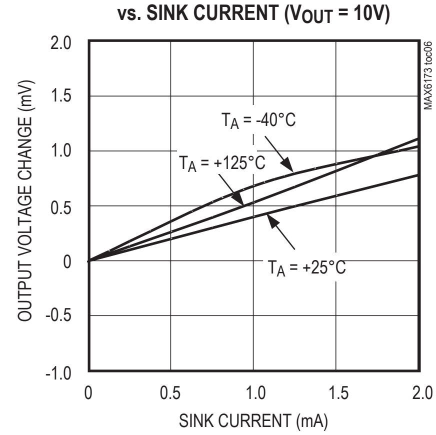
LOAD REGULATION vs. SINK CURRENT (V_{OUT} = 2.5V)



LOAD REGULATION vs. SINK CURRENT (V_{OUT} = 4.096V)



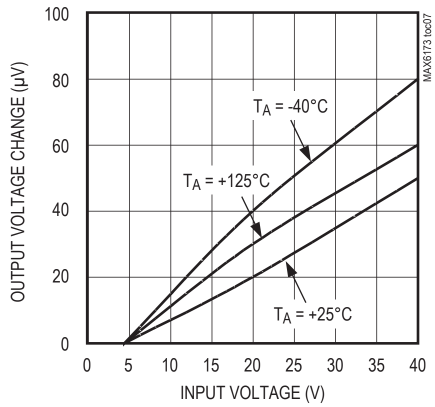
LOAD REGULATION vs. SINK CURRENT (V_{OUT} = 10V)



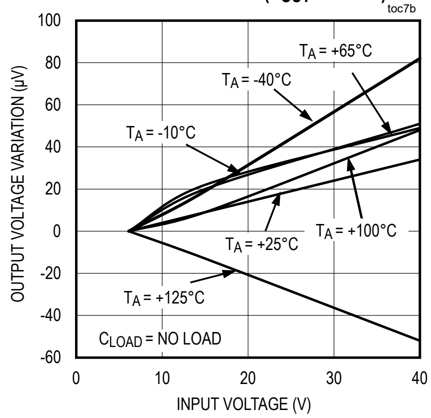
Typical Operating Characteristics (continued)

(V_{IN} = +5V for V_{OUT} = +2.5V, V_{IN} = +15V for V_{OUT} = 4.096V and V_{OUT} = +10V, I_{OUT} = 0, T_A = +25°C, unless otherwise noted.)

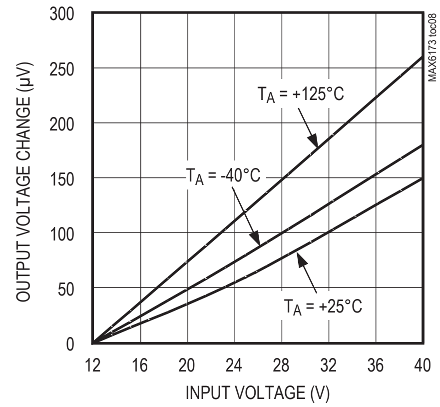
LINE REGULATION vs. TEMPERATURE (V_{OUT} = 2.5V)



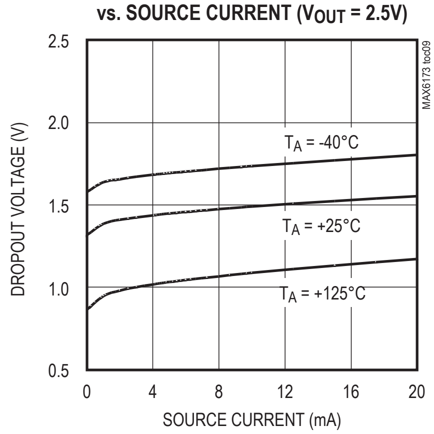
LINE REGULATION vs. TEMPERATURE (V_{OUT} = 4.096V)



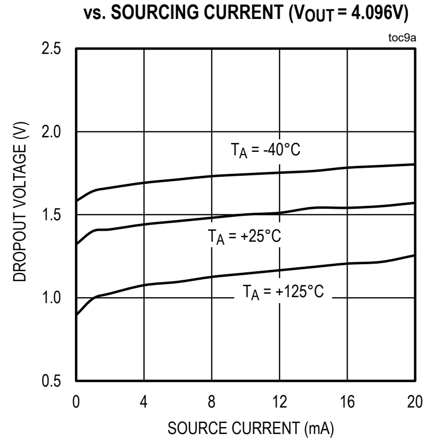
LINE REGULATION vs. TEMPERATURE (V_{OUT} = 10V)



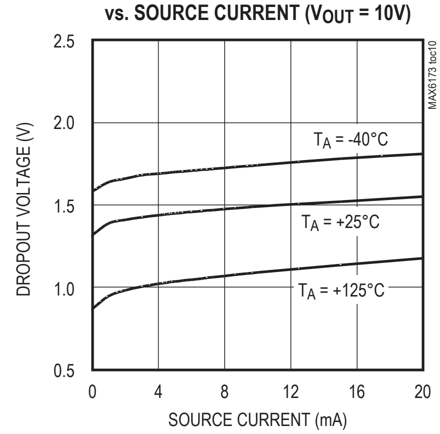
MINIMUM INPUT-OUTPUT DIFFERENTIAL vs. SOURCE CURRENT (V_{OUT} = 2.5V)



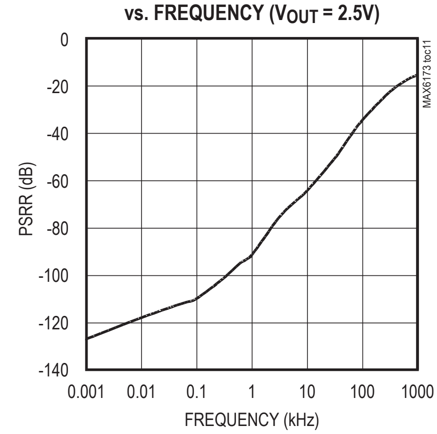
MINIMUM INPUT-OUTPUT DIFFERENTIAL vs. SOURCING CURRENT (V_{OUT} = 4.096V)



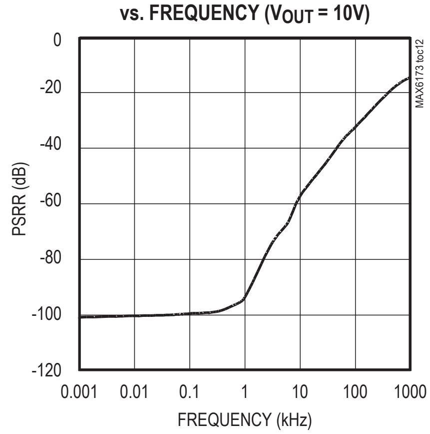
MINIMUM INPUT-OUTPUT DIFFERENTIAL vs. SOURCE CURRENT (V_{OUT} = 10V)



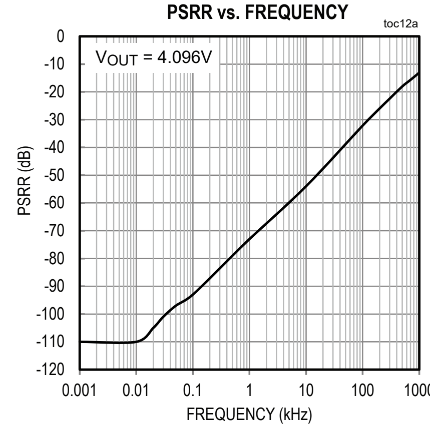
POWER-SUPPLY REJECTION RATIO vs. FREQUENCY (V_{OUT} = 2.5V)



POWER-SUPPLY REJECTION RATIO vs. FREQUENCY (V_{OUT} = 10V)



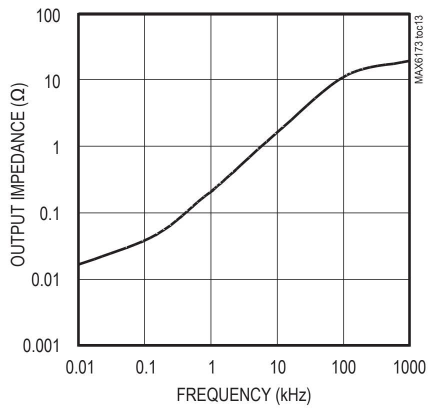
PSRR vs. FREQUENCY



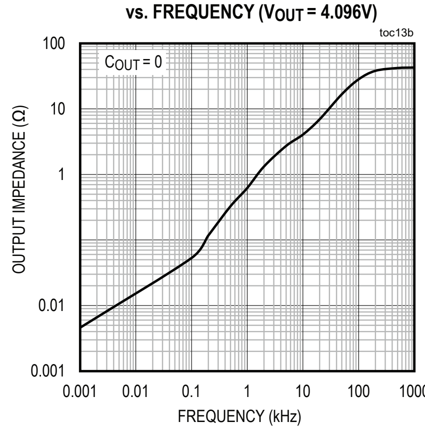
Typical Operating Characteristics (continued)

(V_{IN} = +5V for V_{OUT} = +2.5V, V_{IN} = +15V for V_{OUT} = 4.096V and V_{OUT} = +10V, I_{OUT} = 0, T_A = +25°C, unless otherwise noted.)

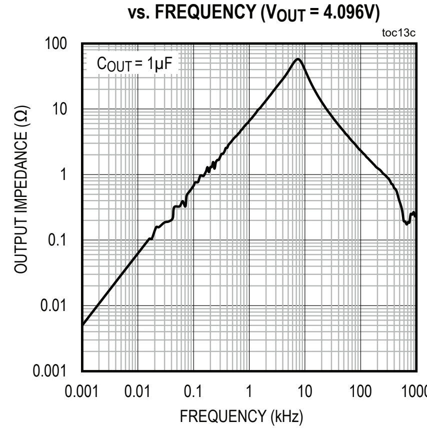
OUTPUT IMPEDANCE vs. FREQUENCY (V_{OUT} = 2.5V)



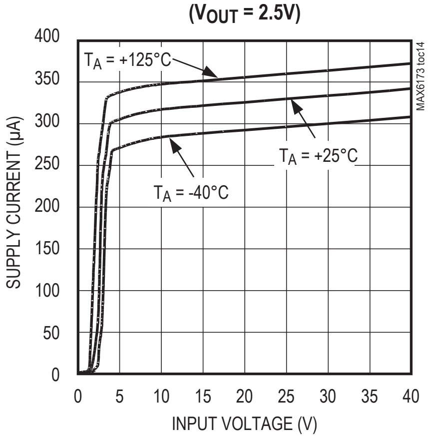
OUTPUT IMPEDANCE vs. FREQUENCY (V_{OUT} = 4.096V)



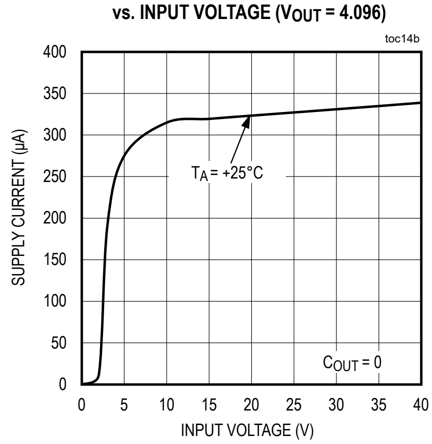
OUTPUT IMPEDANCE vs. FREQUENCY (V_{OUT} = 4.096V)



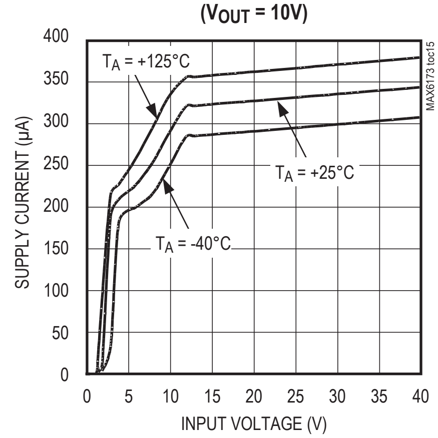
SUPPLY CURRENT vs. INPUT VOLTAGE (V_{OUT} = 2.5V)



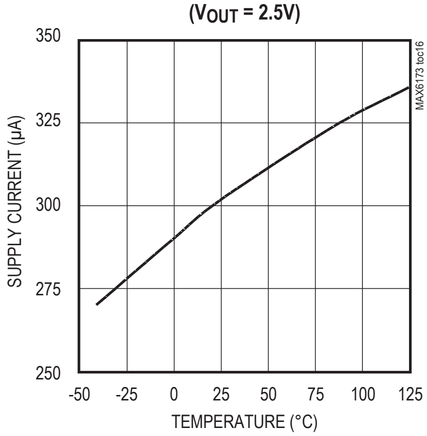
SUPPLY CURRENT vs. INPUT VOLTAGE (V_{OUT} = 4.096)



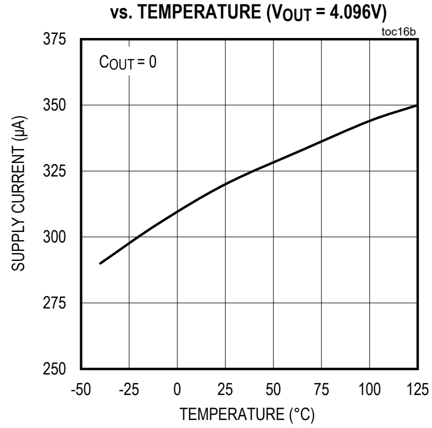
SUPPLY CURRENT vs. INPUT VOLTAGE (V_{OUT} = 10V)



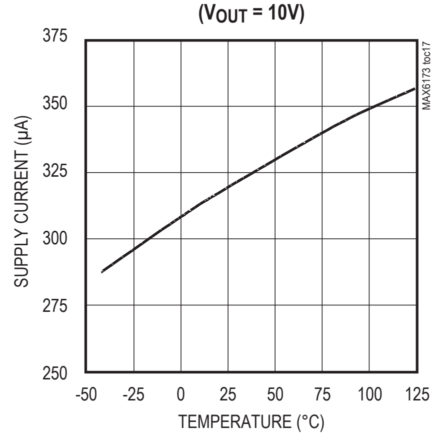
SUPPLY CURRENT vs. TEMPERATURE (V_{OUT} = 2.5V)



SUPPLY CURRENT vs. TEMPERATURE (V_{OUT} = 4.096V)



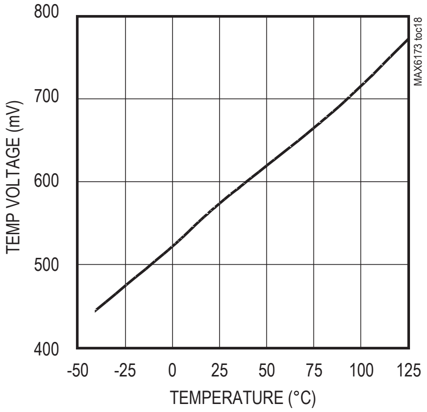
SUPPLY CURRENT vs. TEMPERATURE (V_{OUT} = 10V)



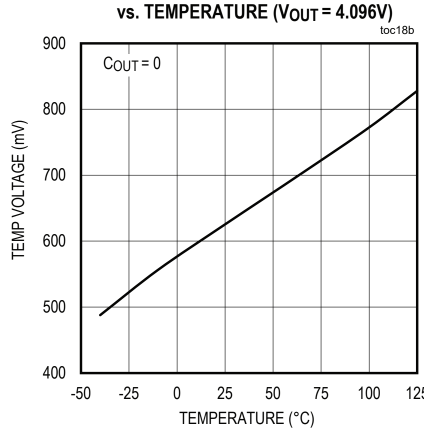
Typical Operating Characteristics (continued)

(V_{IN} = +5V for V_{OUT} = +2.5V, V_{IN} = +15V for V_{OUT} = 4.096V and V_{OUT} = +10V, I_{OUT} = 0, T_A = +25°C, unless otherwise noted.)

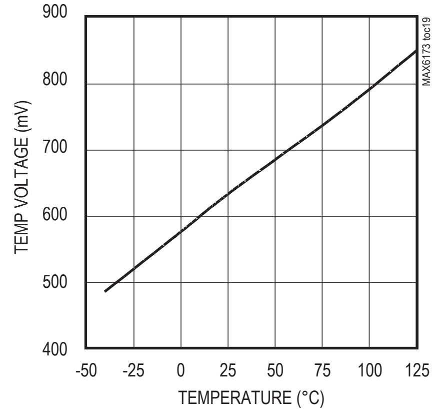
TEMP VOLTAGE vs. TEMPERATURE (V_{OUT} = 2.5V)



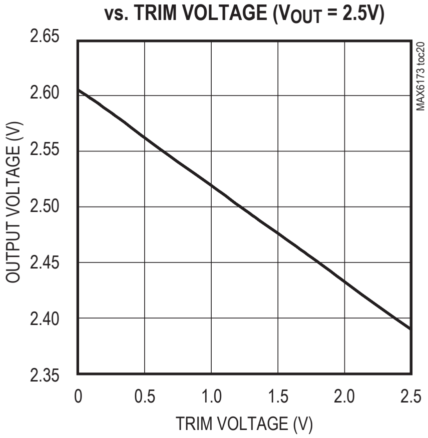
TEMP VOLTAGE vs. TEMPERATURE (V_{OUT} = 4.096V)



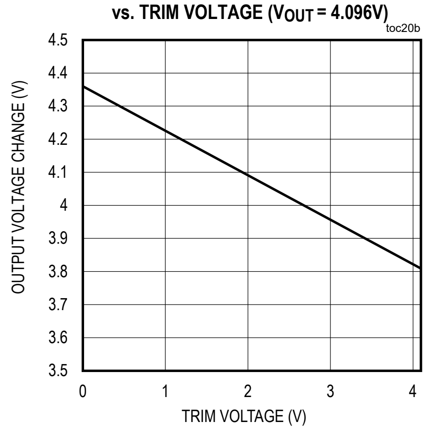
TEMP VOLTAGE vs. TEMPERATURE (V_{OUT} = 10V)



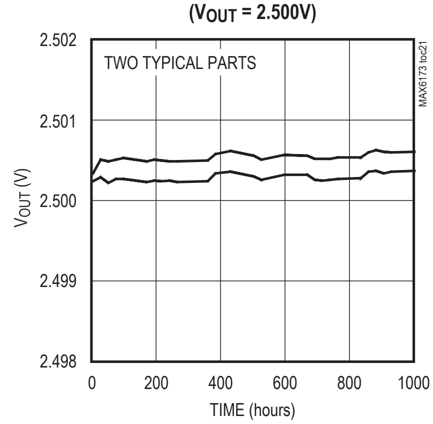
OUTPUT VOLTAGE vs. TRIM VOLTAGE (V_{OUT} = 2.5V)



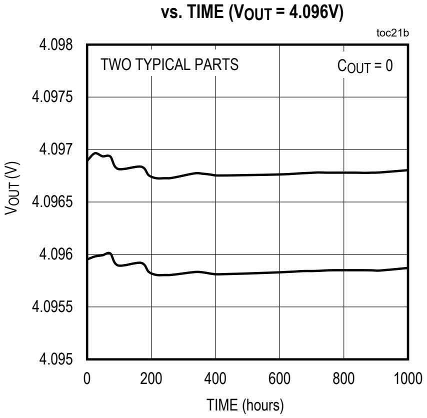
OUTPUT VOLTAGE vs. TRIM VOLTAGE (V_{OUT} = 4.096V)



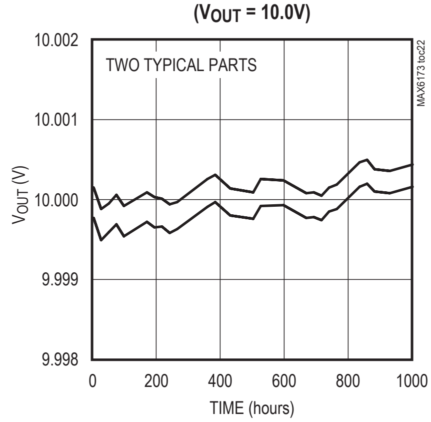
LONG-TERM STABILITY vs. TIME (V_{OUT} = 2.500V)



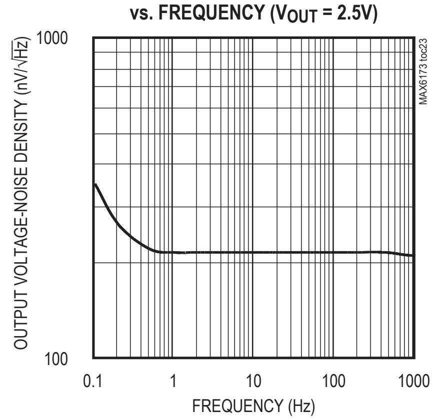
LONG-TERM STABILITY vs. TIME (V_{OUT} = 4.096V)



LONG-TERM STABILITY vs. TIME (V_{OUT} = 10.0V)



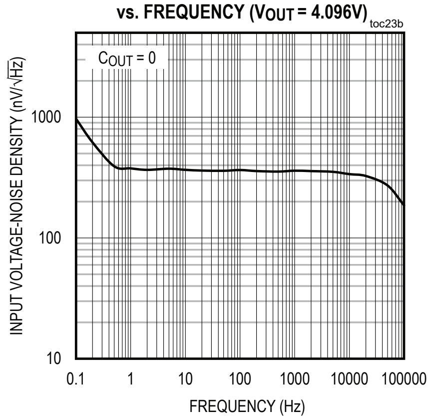
OUTPUT-VOLTAGE NOISE DENSITY vs. FREQUENCY (V_{OUT} = 2.5V)



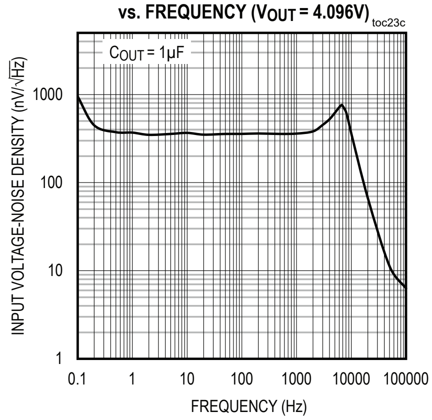
Typical Operating Characteristics (continued)

(V_{IN} = +5V for V_{OUT} = +2.5V, V_{IN} = +15V for V_{OUT} = 4.096V and V_{OUT} = +10V, I_{OUT} = 0, T_A = +25°C, unless otherwise noted.)

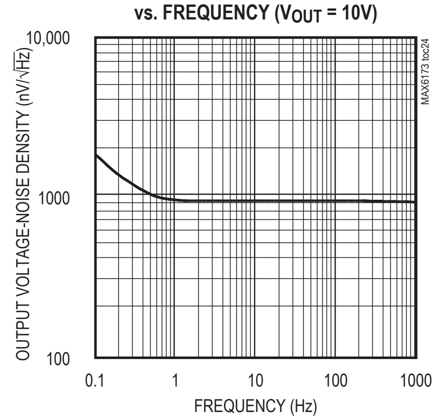
OUTPUT VOLTAGE-NOISE DENSITY vs. FREQUENCY (V_{OUT} = 4.096V)



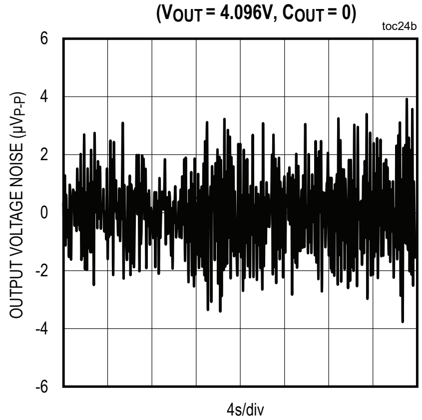
OUTPUT VOLTAGE-NOISE DENSITY vs. FREQUENCY (V_{OUT} = 4.096V)



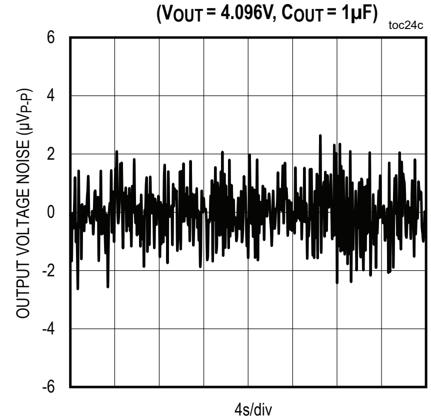
OUTPUT-VOLTAGE NOISE DENSITY vs. FREQUENCY (V_{OUT} = 10V)



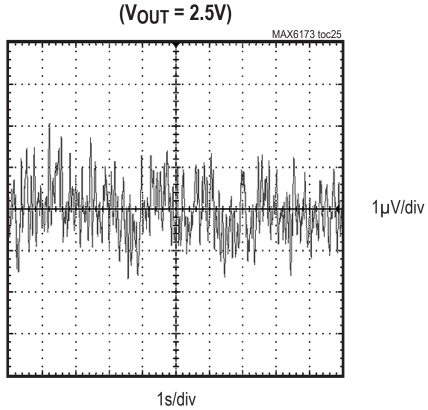
0.1Hz to 10Hz OUTPUT VOLTAGE NOISE (V_{OUT} = 4.096V, C_{OUT} = 0)



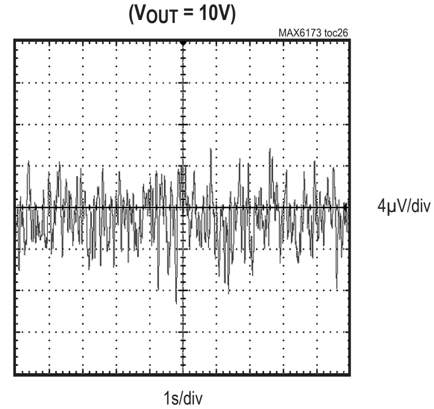
0.1Hz to 10Hz OUTPUT VOLTAGE NOISE (V_{OUT} = 4.096V, C_{OUT} = 1µF)



0.1Hz TO 10Hz OUTPUT NOISE (V_{OUT} = 2.5V)



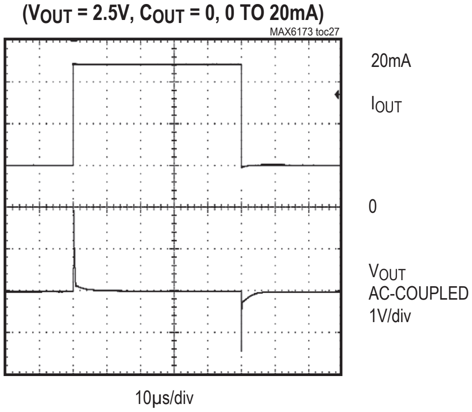
0.1Hz TO 10Hz OUTPUT NOISE (V_{OUT} = 10V)



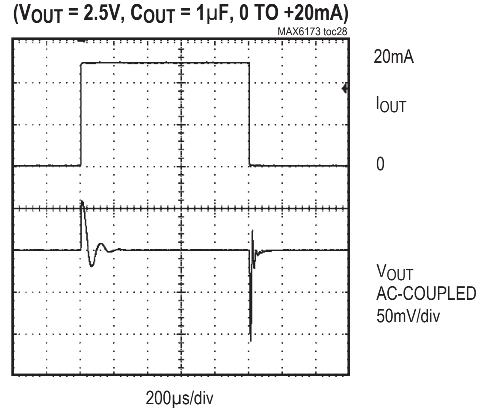
Typical Operating Characteristics (continued)

(V_{IN} = +5V for V_{OUT} = +2.5V, V_{IN} = +15V for V_{OUT} = 4.096V and V_{OUT} = +10V, I_{OUT} = 0, T_A = +25°C, unless otherwise noted.)

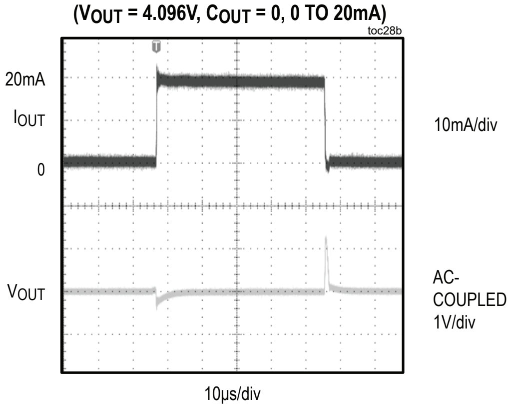
LOAD TRANSIENT (V_{OUT} = 2.5V, C_{OUT} = 0, 0 TO 20mA)



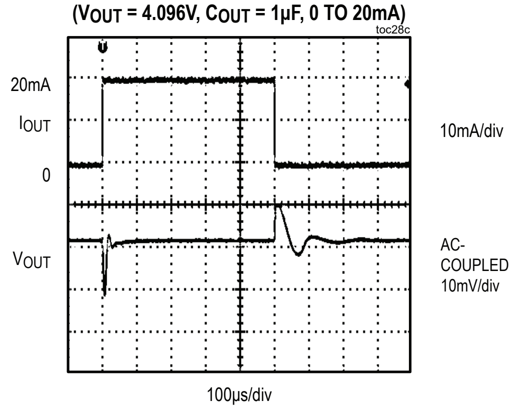
LOAD TRANSIENT (V_{OUT} = 2.5V, C_{OUT} = 1µF, 0 TO +20mA)



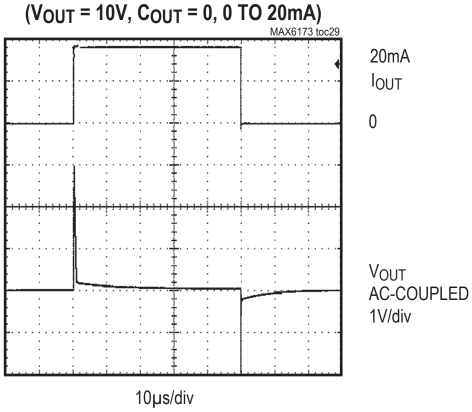
LOAD TRANSIENT (V_{OUT} = 4.096V, C_{OUT} = 0, 0 TO 20mA)



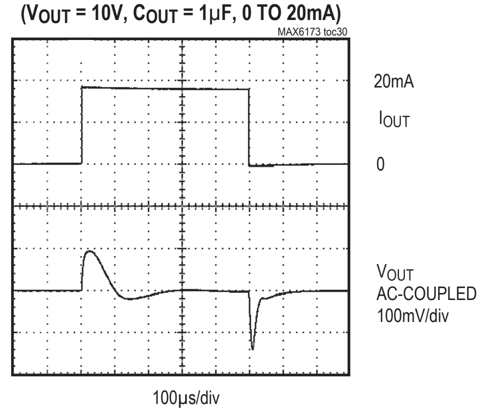
LOAD TRANSIENT (V_{OUT} = 4.096V, C_{OUT} = 1µF, 0 TO 20mA)



LOAD TRANSIENT (V_{OUT} = 10V, C_{OUT} = 0, 0 TO 20mA)



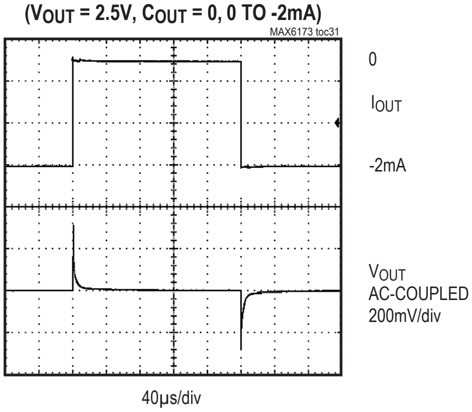
LOAD TRANSIENT (V_{OUT} = 10V, C_{OUT} = 1µF, 0 TO 20mA)



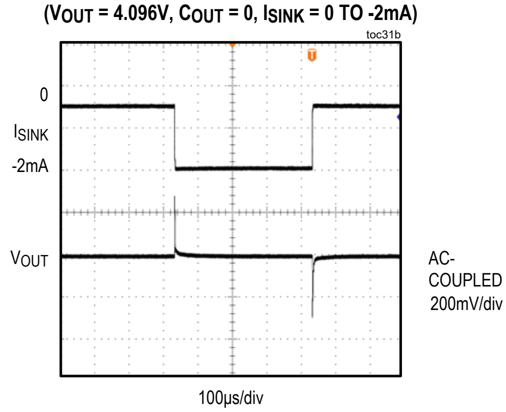
Typical Operating Characteristics (continued)

(V_{IN} = +5V for V_{OUT} = +2.5V, V_{IN} = +15V for V_{OUT} = 4.096V and V_{OUT} = +10V, I_{OUT} = 0, T_A = +25°C, unless otherwise noted.)

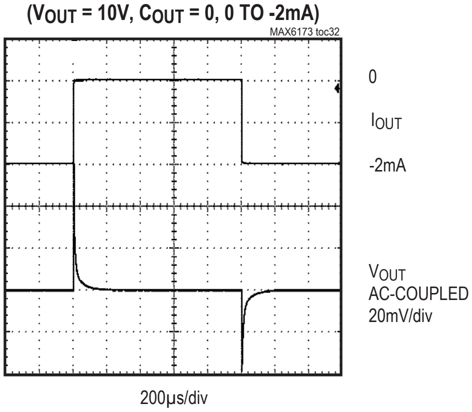
LOAD TRANSIENT
(V_{OUT} = 2.5V, C_{OUT} = 0, 0 TO -2mA)



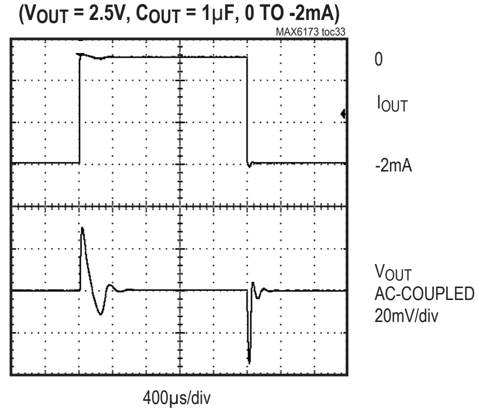
LOAD TRANSIENT
(V_{OUT} = 4.096V, C_{OUT} = 0, I_{SINK} = 0 TO -2mA)



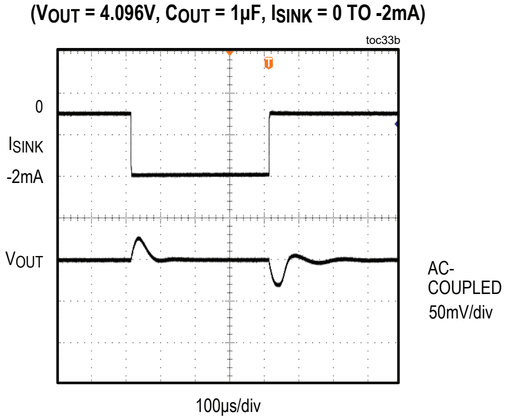
LOAD TRANSIENT
(V_{OUT} = 10V, C_{OUT} = 0, 0 TO -2mA)



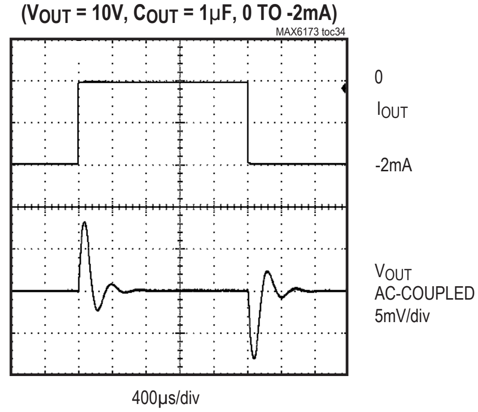
LOAD TRANSIENT
(V_{OUT} = 2.5V, C_{OUT} = 1µF, 0 TO -2mA)



LOAD TRANSIENT
(V_{OUT} = 4.096V, C_{OUT} = 1µF, I_{SINK} = 0 TO -2mA)



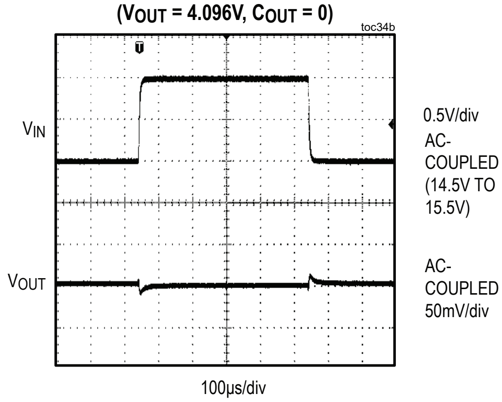
LOAD TRANSIENT
(V_{OUT} = 10V, C_{OUT} = 1µF, 0 TO -2mA)



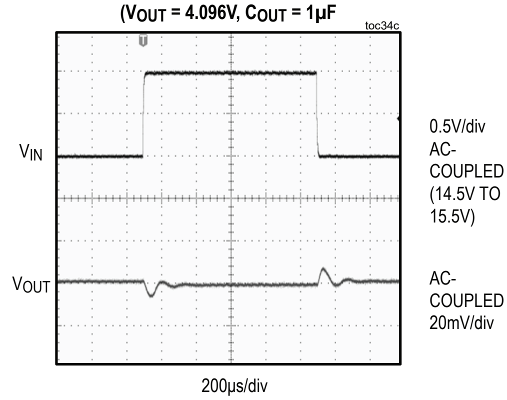
Typical Operating Characteristics (continued)

(V_{IN} = +5V for V_{OUT} = +2.5V, V_{IN} = +15V for V_{OUT} = 4.096V and V_{OUT} = +10V, I_{OUT} = 0, T_A = +25°C, unless otherwise noted.)

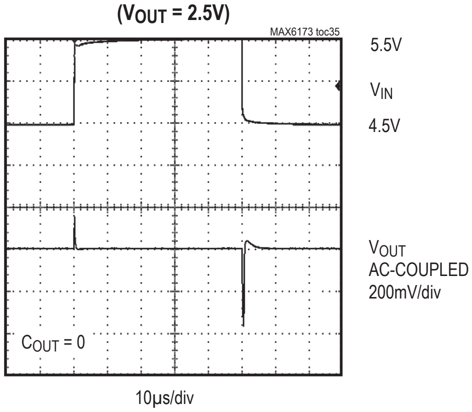
LINE TRANSIENT (V_{OUT} = 4.096V, C_{OUT} = 0)



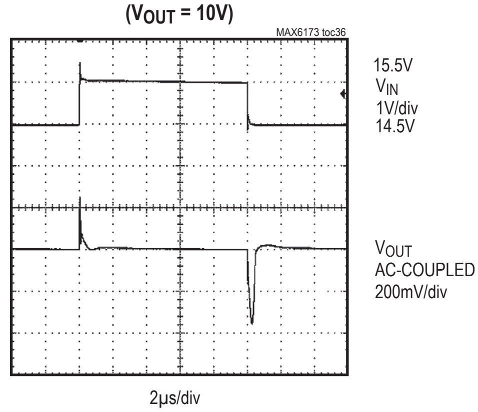
LINE TRANSIENT (V_{OUT} = 4.096V, C_{OUT} = 1µF



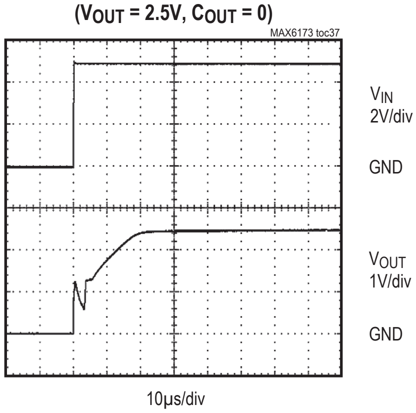
LINE TRANSIENT (V_{OUT} = 2.5V)



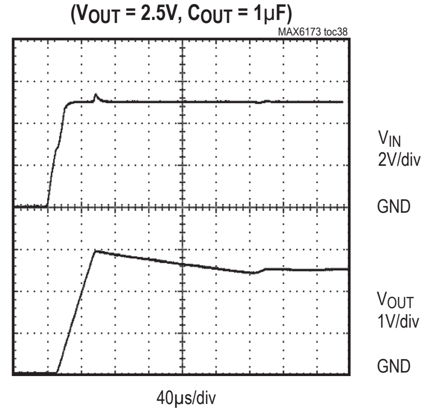
LINE TRANSIENT (V_{OUT} = 10V)



TURN-ON TRANSIENT (V_{OUT} = 2.5V, C_{OUT} = 0)

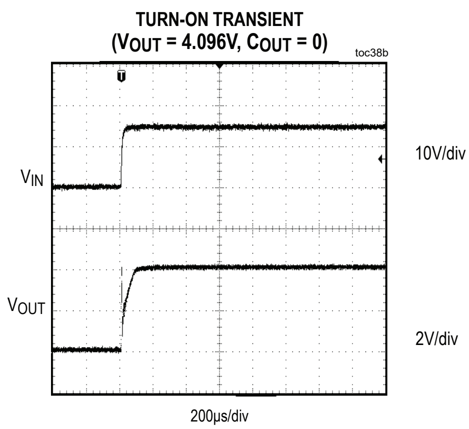


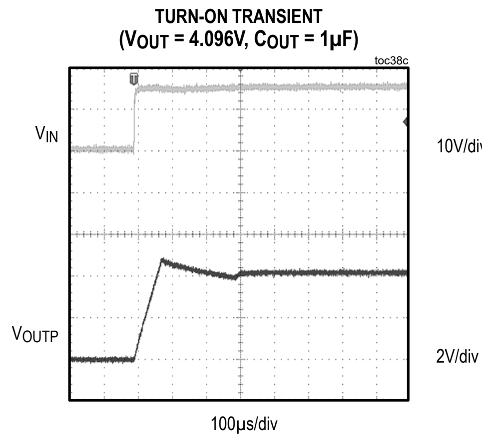
TURN-ON TRANSIENT (V_{OUT} = 2.5V, C_{OUT} = 1µF)

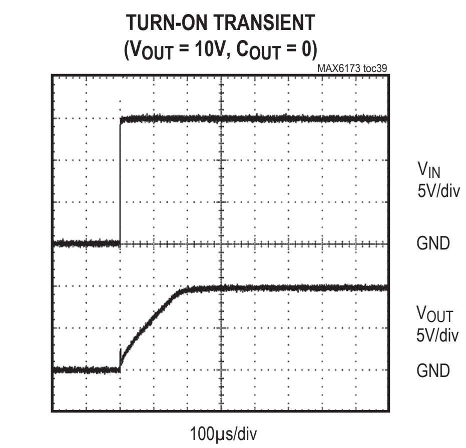


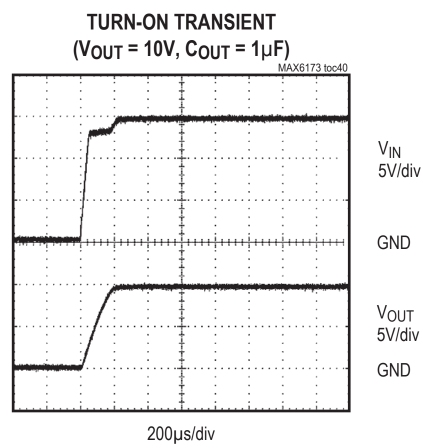
Typical Operating Characteristics (continued)

(V_{IN} = +5V for V_{OUT} = +2.5V, V_{IN} = +15V for V_{OUT} = 4.096V and V_{OUT} = +10V, I_{OUT} = 0, T_A = +25°C, unless otherwise noted.)









Pin Description

PIN	NAME	FUNCTION
1, 8	I.C.	Internally Connected. Do not connect externally.
2	IN	Positive Power-Supply Input
3	TEMP	Temperature Proportional Output Voltage. TEMP generates an output voltage proportional to the die temperature.
4	GND	Ground
5	TRIM	Output Voltage Trim. Connect TRIM to the center of a voltage-divider between OUT and GND for trimming. Leave unconnected to use the preset output voltage.
6	OUT	Output Voltage
7	N.C.	No Connection. Not internally connected.

Detailed Description

The MAX6173–MAX6177 precision voltage references provide accurate preset +2.5V, +3.3V, +4.096V, +5.0V, and +10V reference voltages from up to +40V input voltages. These devices feature a proprietary temperature-coefficient curvature-correction circuit and laser-trimmed thin-film resistors that result in a very low 3ppm/°C temperature coefficient and excellent 0.05% initial accuracy. The MAX6173–MAX6177 draw 340µA of supply current and source 30mA or sink 2mA of load current.

Trimming the Output Voltage

Trim the factory-preset output voltage on the MAX6173–MAX6177 by placing a resistive divider network between OUT, TRIM, and GND.

Use the following formula to calculate the change in output voltage from its preset value:

$$\Delta V_{OUT} = 2 \times (V_{TRIM} - V_{TRIM\ (open)}) \times k$$

where:

V_{TRIM} = 0V to V_{OUT}

$V_{TRIM\ (open)} = V_{OUT}$ (nominal)/2 (typ)

k = ±6% (typ)

For example, use a 50kΩ potentiometer (such as the MAX5436) between OUT, TRIM, and GND with the potentiometer wiper connected to TRIM (see Figure 2). As the TRIM voltage changes from V_{OUT} to GND, the output voltage changes accordingly. Set R2 to 1MΩ or less. Currents through resistors R1 and R2 add to the quiescent supply current.

Temp Output

The MAX6173–MAX6177 provide a temperature output proportional to die temperature. TEMP can be calculated from the following formula:

$$TEMP\ (V) = T_J\ (°K) \times n$$

where T_J = the die temperature,

n = the temperature multiplier,

$$n = \frac{V_{TEMP}(at\ T_J = T_0)}{T_0} \cong 1.9mV/°K$$

T_A = the ambient temperature.

Self-heating affects the die temperature and conversely, the TEMP output. The TEMP equation assumes the output is not loaded. If device power dissipation is negligible, then $T_J \approx T_A$.

Applications Information

Bypassing/Output Capacitance

For the best line-transient performance, decouple the input with a 0.1μF ceramic capacitor as shown in the *Typical Operating Circuit*. Place the capacitor as close to IN as possible. When transient performance is less important, no capacitor is necessary.

The MAX6173–MAX6177 do not require an output capacitor for stability and are stable with capacitive loads up to 100μF. In applications where the load or the supply can experience step changes, a larger output capacitor reduces the amount of overshoot (undershoot) and improves the circuit's transient response. Place output capacitors as close to the devices as possible for best performance.

Supply Current

The MAX6173–MAX6177 consume 320μA (typ) of quiescent supply current. This improved efficiency reduces power dissipation and extends battery life.

Thermal Hysteresis

Thermal 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 typical thermal hysteresis value is 120ppm.

Turn-On Time

The MAX6173–MAX6177 typically turn on and settle to within 0.1% of the preset output voltage in 150μs (2.5V output). The turn-on time can increase up to 150μs with the device operating with a 1μF load.

Short-Circuited Outputs

The MAX6173–MAX6177 feature a short-circuit-protected output. Internal circuitry limits the output current to 60mA when short circuiting the output to ground. The output current is limited to 3mA when short circuiting the output to the input.

Temperature Coefficient vs. Operating Temperature Range for a 1 LSB Maximum Error

In a data converter application, the reference voltage of the converter must stay within a certain limit to keep the error in the data converter smaller than the resolution limit through the operating temperature range. Figure 1 shows the maximum allowable reference-voltage temperature coefficient to keep the conversion error to less than 1 LSB, as a function of the operating temperature range (T_{MAX} - T_{MIN}) with the converter resolution as a parameter. The graph assumes the reference-voltage temperature coefficient as the only parameter affecting accuracy.

In reality, the absolute static accuracy of a data converter is dependent on the combination of many parameters such as integral nonlinearity, differential nonlinearity, offset error, gain error, as well as voltage-reference changes.

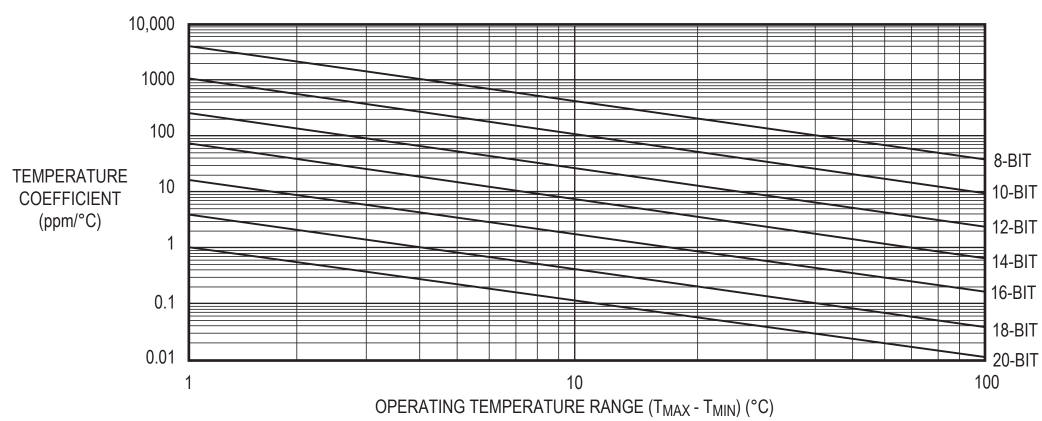


Figure 1. Temperature Coefficient vs. Operating Temperature Range for a 1 LSB Maximum Error

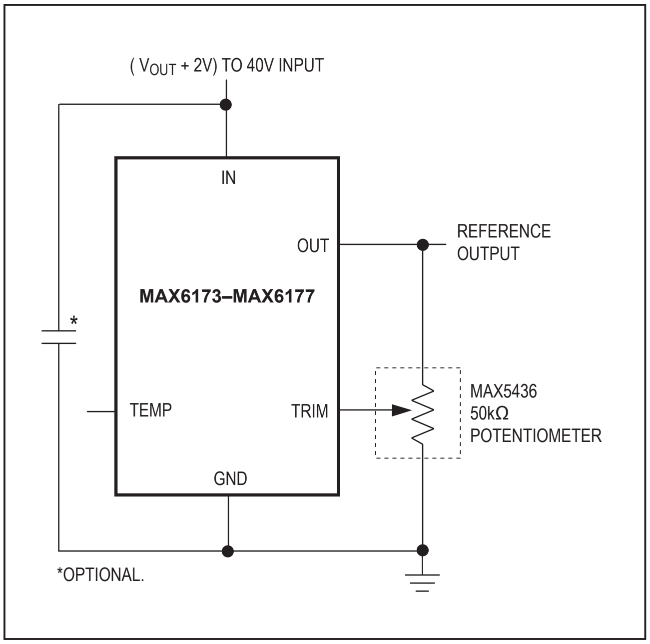
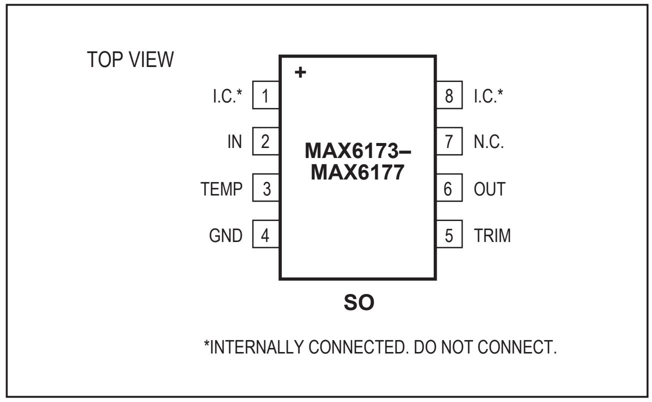


Figure 2. Applications Circuit Using the MAX5436 Potentiometer

Pin Configuration



Chip Information

PROCESS: BiCMOS

Package Information

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 TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
8 SO	S8+4	21-0041	90-0096
8 SO	S8+22	21-0041	90-0096

Ordering Information/Selector Guide

PART	TEMP RANGE	PIN-PACKAGE	OUTPUT VOLTAGE (V)	TEMPERATURE COEFFICIENT (ppm/°C) -40°C TO +125°C	INITIAL ACCURACY (%)
MAX6173AASA+	-40°C to +125°C	8 SO	2.500	3	0.06
MAX6173BASA+	-40°C to +125°C	8 SO	2.500	10	0.10
MAX6173BASA/V+T	-40°C to +125°C	8 SO	2.500	3	0.06
MAX6174AASA+	-40°C to +125°C	8 SO	4.096	3	0.06
MAX6174BASA+	-40°C to +125°C	8 SO	4.096	10	0.10
MAX6174BASA/V+	-40°C to +125°C	8 SO	4.096	10	0.10
MAX6174BASA/V+T	-40°C to +125°C	8 SO	4.096	10	0.10
MAX6175AASA+	-40°C to +125°C	8 SO	5.000	3	0.06
MAX6175BASA+	-40°C to +125°C	8 SO	5.000	10	0.10
MAX6175BASA/V+	-40°C to +125°C	8 SO	5.000	10	0.10
MAX6176AASA+	-40°C to +125°C	8 SO	10.000	3	0.05
MAX6176BASA+	-40°C to +125°C	8 SO	10.000	10	0.10
MAX6177AASA+	-40°C to +125°C	8 SO	3.300	3	0.06
MAX6177BASA+	-40°C to +125°C	8 SO	3.300	10	0.10

+Denotes a lead(Pb)-free/RoHS-compliant package.
/V denotes an automotive qualified part

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	6/04	Initial release	—
1	2/11	Added automotive grade part, lead-free information, and soldering temperature	1, 2
2	3/14	Updated package code in *Package Information*	14
3	6/14	Updated *Ordering Information*, *Electrical Characteristics*, and *Typical Operating Characteristics*	1, 4, 5, 8
4	9/14	Updated *Typical Operating Characteristics*	7–14
5	9/14	Updated *Typical Operating Characteristics*	7–15
6	12/17	Added AEC statement to *Benefits and Features* section	1
7	3/18	Updated *Ordering Informaiton* table	18
8	3/18	Updated *Absolute Maximum Ratings section and Electrical Characteristics* table	2–6
9	3/18	Updated *Absolute Maximum Ratings section*	2
10	10/18	Update *Applications*, *Package Thermal Characteristics*, *Package Information*, and *Ordering Information/Selector Guide*	1, 2, 18
11	4/19	Updated *General Description* section	1

For pricing, delivery, and ordering information, please visit Maxim Integrated's online storefront at https://www.maximintegrated.com/en/storefront/storefront.html.

