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19-3168; Rev 1; 4/04

High-Precision Voltage Reference with Temperature Sensor

MAX6143

General Description

The MAX6143 is a low-noise, high-precision voltage reference. The device features 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 MAX6143 provides a TEMP output where the output voltage is proportional to die temperature, making the device suitable for a wide variety of temperature-sensing applications. The device also provides a TRIM input, allowing fine trimming of the output voltage with a resistive-divider network. Low temperature drift and low noise make the MAX6143 ideal for use with high-resolution A/D or D/A converters.

The MAX6143 provides accurate preset +2.5V, +3.3V, +4.096V, +5.0V, and +10V reference voltages and accepts input voltages up to +40V. The device draws 340µA of supply current and sources 30mA or sinks 2mA of load current. The active-low shutdown feature ($\overline{SHDN}$) reduces supply current to 0.01µA. The MAX6143 uses bandgap technology for low-noise performance and excellent accuracy. The MAX6143 does not require an output bypass capacitor for stability, and is stable with capacitive loads up to 100µF. Eliminating the output bypass capacitor saves valuable board area in space-critical applications.

The MAX6143 is available in an 8-pin SO package and operates over the automotive (-40°C to +125°C) temperature range.

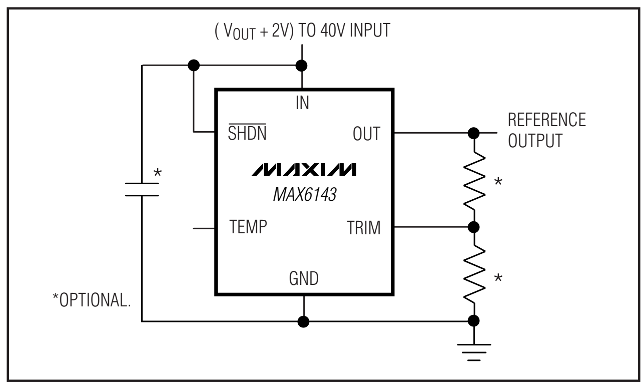
Applications

- A/D Converters
- D/A Converters
- Digital Voltmeters
- Voltage Regulators
- Threshold Detectors

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)
- ♦ Low 0.01µA Shutdown Current
- ♦ 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

Typical Operating Circuit



Pin Configuration appears at end of data sheet.

Ordering Information/Selector Guide

PART	TEMP RANGE	PIN-PACKAGE	OUTPUT VOLTAGE (V)	TEMPERATURE COEFFICIENT (ppm/°C) 40°C TO +125°C	INITIAL ACCURACY (%)
MAX6143AASA25	-40°C to +125°C	8 SO	2.500	3	0.06
MAX6143BASA25	-40°C to +125°C	8 SO	2.500	10	0.10
MAX6143AASA33	-40°C to +125°C	8 SO	3.300	3	0.06
MAX6143BASA33	-40°C to +125°C	8 SO	3.300	10	0.10
MAX6143AASA41	-40°C to +125°C	8 SO	4.096	3	0.06
MAX6143BASA41	-40°C to +125°C	8 SO	4.096	10	0.10
MAX6143AASA50	-40°C to +125°C	8 SO	5.000	3	0.06
MAX6143BASA50	-40°C to +125°C	8 SO	5.000	10	0.10
MAX6143AASA10	-40°C to +125°C	8 SO	10.000	3	0.05
MAX6143BASA10	-40°C to +125°C	8 SO	10.000	10	0.10

High-Precision Voltage Reference with Temperature Sensor

ABSOLUTE MAXIMUM RATINGS

IN to GND .... -0.3V to +42V
OUT, $\overline{SHDN}$, TRIM, TEMP to GND .... -0.3V to (V_{IN} + 0.3V)
Output Short Circuit to GND 5s
Continuous Power Dissipation (T_A = +70°C)
8-Pin SO (derate 5.9mW/°C above +70°C) 471mW
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

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—MAX6143_25 (V_{OUT} = 2.5V)

($V_{IN} = V_{\overline{SHDN}}$ = +5V, 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
OUTPUT							
Output Voltage	V_{OUT}	No load, T_A = +25°C	MAX6143A_25 (0.06%)	2.4985	2.5	2.5015	V
			MAX6143B_25 (0.1%)	2.4975	2.5	2.5025	
Output Adjustment Range	ΔV_{TRIM}	R_{POT} = 10kΩ		±3	±6		%
Output-Voltage Temperature Coefficient (Note 2)	TCV_{OUT}	T_A = -40°C to +125°C	MAX6143AASA		1.5	3	ppm/°C
			MAX6143BASA		3	10	
Line Regulation (Note 3)	ΔV_{OUT} / ΔV_{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 3)	ΔV_{OUT} / ΔI_{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 4)	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, normal operation	T_A = +25°C		300	450	µA
			T_A = -40°C to +125°C			600	
Shutdown Supply Current	$I_{\overline{SHDN}}$	No load, $V_{\overline{SHDN}}$ < 0.8V	T_A = -40°C to +125°C		0.01	5	µA

ELECTRICAL CHARACTERISTICS—MAX6143_25 (V_{OUT} = 2.5V) (continued)

(V_{IN} = $V_{\overline{SHDN}}$ = +5V, 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
SHUTDOWN ($\overline{SHDN}$)						
Logic-High Input Voltage	V_{IH}		2.0			V
Logic-Low Input Voltage	V_{IL}				0.8	V
Logic-High Input Current	I_{IH}				20	µA
Logic-Low Input Current	I_{IL}				2	µA
TEMP OUTPUT						
TEMP Output Voltage	V_{TEMP}			570		mV
TEMP Temperature Coefficient	TC_{TEMP}			1.9		mV/°C

ELECTRICAL CHARACTERISTICS—MAX6143_33 (V_{OUT} = 3.3V)

(V_{IN} = $V_{\overline{SHDN}}$ = +10V, 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
OUTPUT							
Output Voltage	V_{OUT}	No load, T_A = +25°C	MAX6143A_33 (0.06%)	3.2980	3.3	3.3020	V
			MAX6143B_33 (0.1%)	3.2967	3.3	3.3033	
Output Adjustment Range	ΔV_{TRIM}	R_{POT} = 10kΩ		±3	±6		%
Output-Voltage Temperature Coefficient (Note 2)	TCV_{OUT}	T_A = -40°C to +125°C	MAX6143AASA		1.5	3	ppm/°C
			MAX6143BASA		3	10	
Line Regulation (Note 3)	ΔV_{OUT} / ΔV_{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 3)	ΔV_{OUT} / ΔI_{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 4)	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

High-Precision Voltage Reference with Temperature Sensor

ELECTRICAL CHARACTERISTICS—MAX6143_33 (V_{OUT} = 3.3V) (continued)

(V_{IN} = $V_{\overline{SHDN}}$ = +10V, 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
INPUT							
Supply Voltage Range	V_{IN}	Guaranteed by line regulation test		5.3		40.0	V
Quiescent Supply Current	I_{IN}	No load, normal operation	T_A = +25°C		320	500	µA
			T_A = -40°C to +125°C			650	
Shutdown Supply Current	$I_{\overline{SHDN}}$	No load, $V_{\overline{SHDN}}$ < 0.8V	T_A = -40°C to +125°C		0.01	5	µA
SHUTDOWN ($\overline{SHDN}$)							
Logic-High Input Voltage	V_{IH}			2.0			V
Logic-Low Input Voltage	V_{IL}					0.8	V
Logic-High Input Current	I_{IH}					20	µA
Logic-Low Input Current	I_{IL}					2	µA
TEMP OUTPUT							
TEMP Output Voltage	V_{TEMP}				630		mV
TEMP Temperature Coefficient	TC_{TEMP}				2.1		mV/°C

ELECTRICAL CHARACTERISTICS—MAX6143_41 (V_{OUT} = 4.096V)

(V_{IN} = $V_{\overline{SHDN}}$ = +10V, 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
OUTPUT							
Output Voltage	V_{OUT}	No load, T_A = +25°C	MAX6143A_41 (0.06%)	4.0935	4.096	4.0985	V
			MAX6143B_41 (0.1%)	4.0919	4.096	4.1001	
Output Adjustment Range	ΔV_{TRIM}	R_{POT} = 10kΩ		±3	±6		%
Output-Voltage Temperature Coefficient (Note 2)	TCV_{OUT}	T_A = -40°C to +125°C	MAX6143AASA		1.5	3	ppm/°C
			MAX6143BASA		3	10	
Line Regulation (Note 3)	$\Delta V_{OUT}/\Delta V_{IN}$	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 3)	$\Delta V_{OUT}/\Delta I_{OUT}$	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 4)	ΔV_{OUT}/cycle				120		ppm
Long-Term Stability	ΔV_{OUT}/time	1000 hours at T_A = +25°C			50		ppm

ELECTRICAL CHARACTERISTICS—MAX6143_41 (V_{OUT} = 4.096V) (continued)

(V_{IN} = $V_{\overline{SHDN}}$ = +10V, 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
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, normal operation	T_A = +25°C		320	500	µA
			T_A = -40°C to +125°C			650	
Shutdown Supply Current	$I_{\overline{SHDN}}$	No load, $V_{\overline{SHDN}}$ < 0.8V	T_A =-40°C to +125°C		0.01	5	µA
SHUTDOWN ($\overline{SHDN}$)							
Logic-High Input Voltage	V_{IH}			2.0			V
Logic-Low Input Voltage	V_{IL}					0.8	V
Logic-High Input Current	I_{IH}					20	µA
Logic-Low Input Current	I_{IL}					2	µA
TEMP OUTPUT							
TEMP Output Voltage	V_{TEMP}				630		mV
TEMP Temperature Coefficient	TC_{TEMP}	(0.06%)			2.1		mV/°C

ELECTRICAL CHARACTERISTICS—MAX6143_50 (V_{OUT} = 5.0V)

(V_{IN} = $V_{\overline{SHDN}}$ = +15V, 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
OUTPUT							
Output Voltage	V_{OUT}	No load, T_A = +25°C	MAX6143A_50 (0.06%)	4.9970	5.0	5.0030	V
			MAX6143B_50 (0.1%)	4.9950	5.0	5.0050	
Output Adjustment Range	ΔV_{TRIM}	R_{POT} = 10kΩ		±3	±6		%
Output-Voltage Temperature Coefficient (Note 2)	TCV_{OUT}	T_A = -40°C to +125°C	MAX6143AASA		1.5	3	ppm/°C
			MAX6143BASA		3	10	
Line Regulation (Note 3)	ΔV_{OUT} / ΔV_{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 3)	ΔV_{OUT} / ΔI_{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	

ELECTRICAL CHARACTERISTICS—MAX6143_50 (V_{OUT} = 5.0V) (continued)

(V_{IN} = $V_{\overline{SHDN}}$ = +15V, 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
Output Short-Circuit Current	I_{SC}	OUT shorted to GND			60		mA
		OUT shorted to IN			3		
Temperature Hysteresis (Note 4)	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		40	V
Quiescent Supply Current	I_{IN}	No load, normal operation	T_A = +25°C		320	550	µA
			T_A = -40°C to +125°C			700	
Shutdown Supply Current	$I_{\overline{SHDN}}$	No load, $V_{\overline{SHDN}}$ < 0.8V	T_A = -40°C to +125°C		0.01	5	µA
SHUTDOWN ($\overline{SHDN}$)							
Logic-High Input Voltage	V_{IH}			2.0			V
Logic-Low Input Voltage	V_{IL}					0.8	V
Logic-High Input Current	I_{IH}					20	µA
Logic-Low Input Current	I_{IL}					2	µA
TEMP OUTPUT							
TEMP Output Voltage	V_{TEMP}				630		mV
TEMP Temperature Coefficient	TC_{TEMP}				2.1		mV/°C

ELECTRICAL CHARACTERISTICS—MAX6143_10 (V_{OUT} = 10V)

(V_{IN} = $V_{\overline{SHDN}}$ = +15V, 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
OUTPUT							
Output Voltage	V_{OUT}	No load, T_A = +25°C	MAX6143A_10 (0.05%)	9.995	10.0	10.005	V
			MAX6143B_10 (0.1%)	9.990	10.0	10.010	
Output Adjustment Range	ΔV_{TRIM}	R_{POT} = 10kΩ		±3	±6		%
Output-Voltage Temperature Coefficient (Note 2)	TCV_{OUT}	T_A = -40°C to +125°C	MAX6143AASA		1.5	3	ppm/°C
			MAX6143BASA		3	10	
Line Regulation (Note 3)	$\Delta V_{OUT}/\Delta V_{IN}$	12V ≤ V_{IN} ≤ 40V	T_A = +25°C		0.6	5	ppm/V
			T_A = -40°C to +125°C		0.8	10	

ELECTRICAL CHARACTERISTICS—MAX6143_10 (V_{OUT} = 10V) (continued)

(V_{IN} = $V_{\overline{SHDN}}$ = +15V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

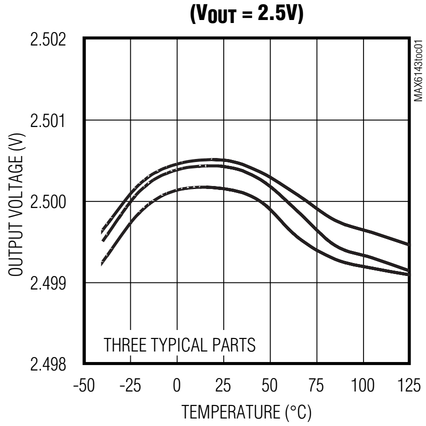
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Load Regulation (Note 3)	$\Delta V_{OUT}/\Delta I_{OUT}$	Sourcing: 0 ≤ I_{OUT} ≤ 10mA	T_A = +25°C		2	10	ppm/mA
			T_A = -40°C to +125°C		2	15	
		Sinking: -0.6mA ≤ I_{OUT} ≤ 0	T_A = +25°C		50	500	
			T_A = -40°C to +125°C		90	900	
Output Short-Circuit Current	I_{SC}	OUT shorted to GND			60		mA
		OUT shorted to IN			3		
Temperature Hysteresis (Note 4)	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		40	V
Quiescent Supply Current	I_{IN}	No load, normal operation	T_A = +25°C		340	550	µA
			T_A = -40°C to +125°C			700	
Shutdown Supply Current	$I_{\overline{SHDN}}$	No load, $V_{\overline{SHDN}}$ < 0.8V	T_A = -40°C to +125°C		0.01	5	µA
SHUTDOWN ($\overline{SHDN}$)							
Logic-High Input Voltage	V_{IH}			2.0			V
Logic-Low Input Voltage	V_{IL}					0.8	V
Logic-High Input Current	I_{IH}					20	µA
Logic-Low Input Current	I_{IL}					2	µA
TEMP OUTPUT							
TEMP Output Voltage	V_{TEMP}				630		mV
TEMP Temperature Coefficient	TC_{TEMP}				2.1		mV/°C

Note 1: 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 2: Temperature coefficient is defined as ΔV_{OUT} divided by the temperature range.
Note 3: Line and load regulation specifications do not include the effects of self-heating.
Note 4: Thermal hysteresis is defined as the change in +25°C output voltage before and after cycling the device from T_{MAX} to T_{MIN}.

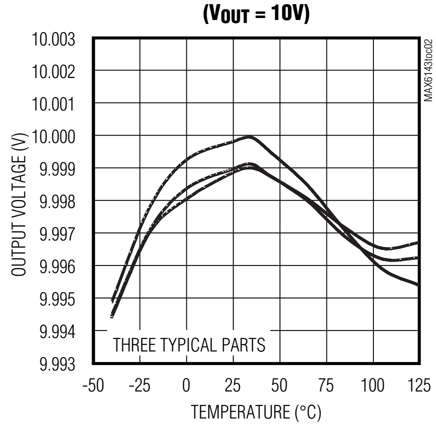
Typical Operating Characteristics

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

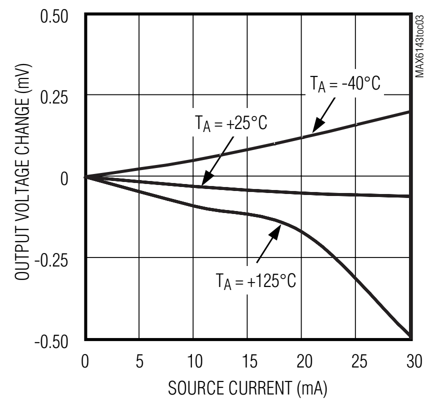
OUTPUT VOLTAGE vs. TEMPERATURE (V_{OUT} = 2.5V)



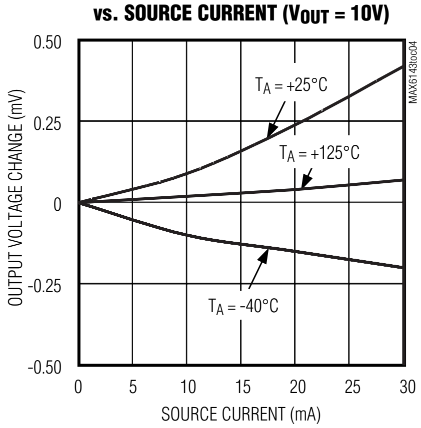
OUTPUT VOLTAGE vs. TEMPERATURE (V_{OUT} = 10V)



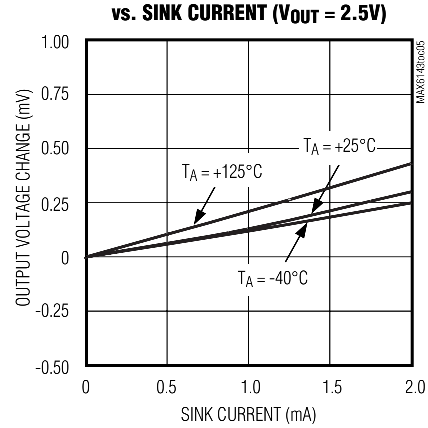
LOAD REGULATION vs. SOURCE CURRENT (V_{OUT} = 2.5V)



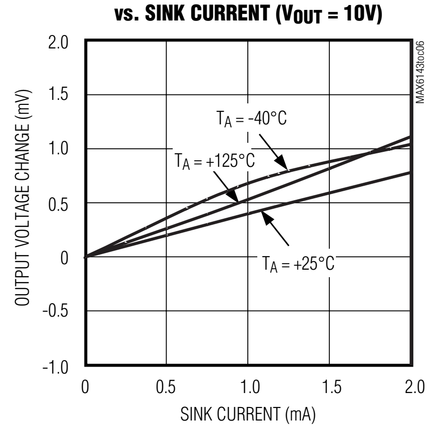
LOAD REGULATION vs. SOURCE CURRENT (V_{OUT} = 10V)



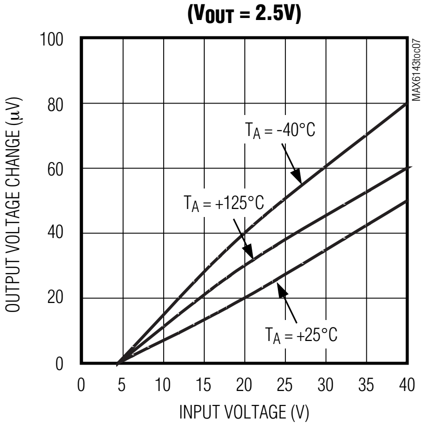
LOAD REGULATION vs. SINK CURRENT (V_{OUT} = 2.5V)



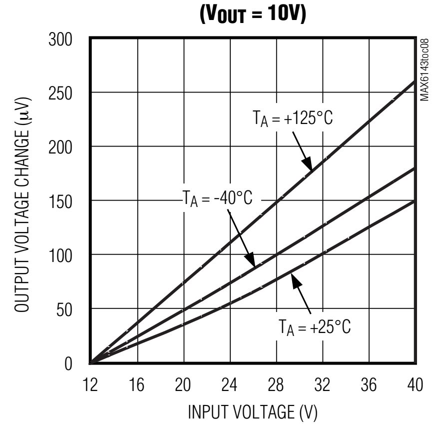
LOAD REGULATION vs. SINK CURRENT (V_{OUT} = 10V)



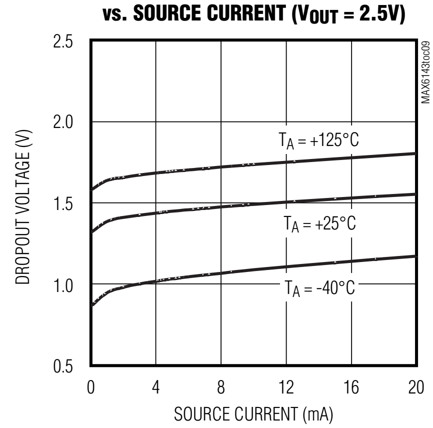
LINE REGULATION vs. TEMPERATURE (V_{OUT} = 2.5V)



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



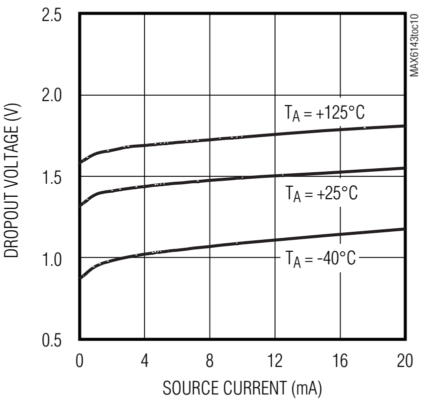
MINIMUM INPUT-OUTPUT DIFFERENTIAL vs. SOURCE CURRENT (V_{OUT} = 2.5V)



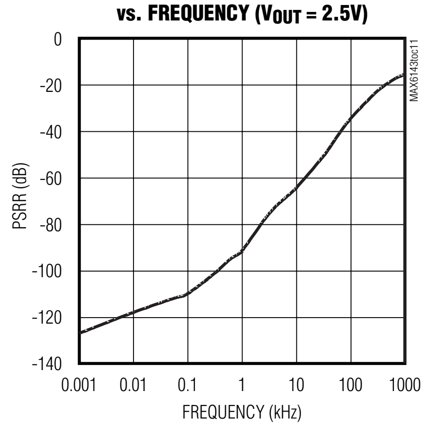
Typical Operating Characteristics (continued)

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

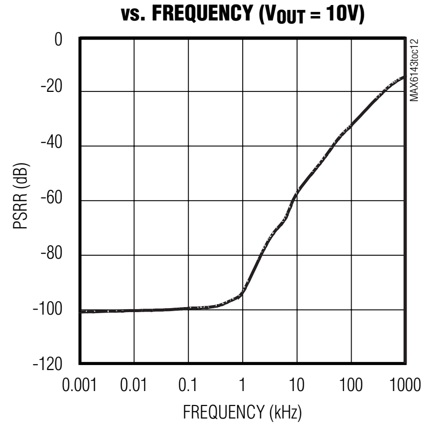
MINIMUM INPUT-OUTPUT DIFFERENTIAL vs. SOURCE CURRENT (V_{OUT} = 10V)



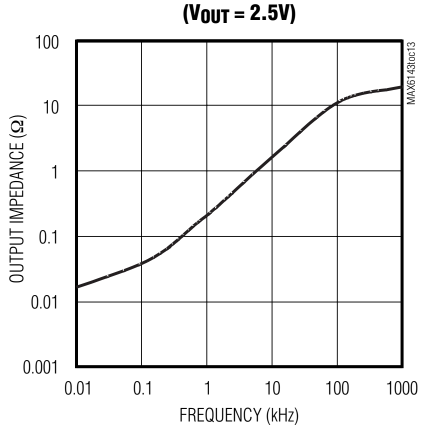
POWER-SUPPLY REJECTION RATIO vs. FREQUENCY (V_{OUT} = 2.5V)



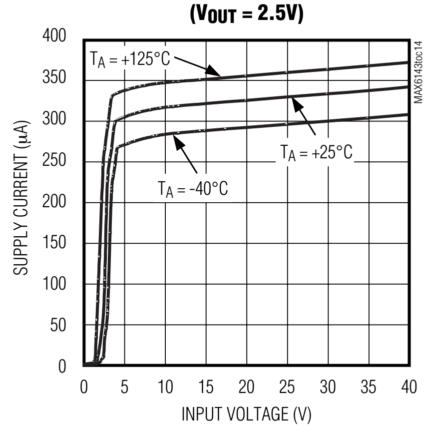
POWER-SUPPLY REJECTION RATIO vs. FREQUENCY (V_{OUT} = 10V)



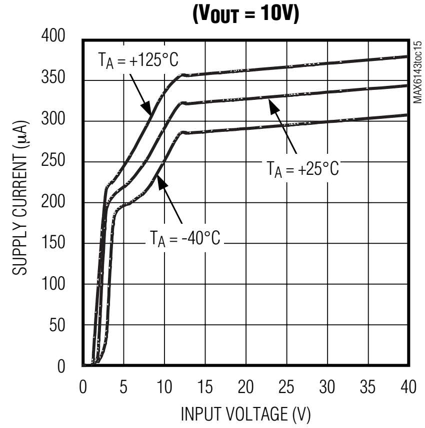
OUTPUT IMPEDANCE vs. FREQUENCY (V_{OUT} = 2.5V)



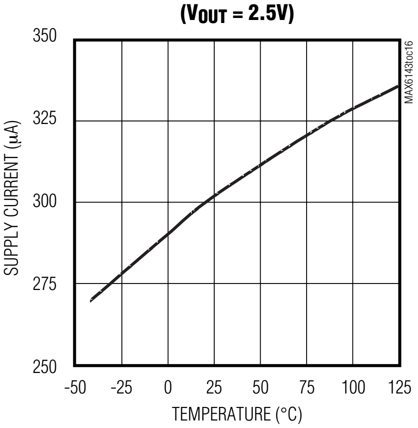
SUPPLY CURRENT vs. INPUT VOLTAGE (V_{OUT} = 2.5V)



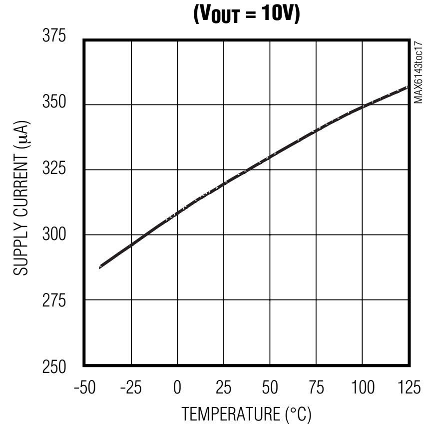
SUPPLY CURRENT vs. INPUT VOLTAGE (V_{OUT} = 10V)



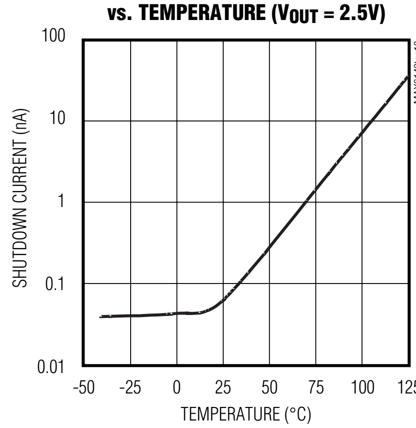
SUPPLY CURRENT vs. TEMPERATURE (V_{OUT} = 2.5V)



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



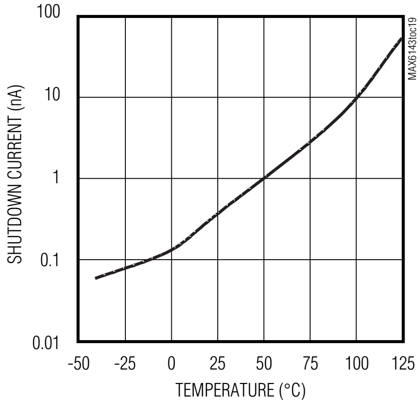
SHUTDOWN SUPPLY CURRENT vs. TEMPERATURE (V_{OUT} = 2.5V)



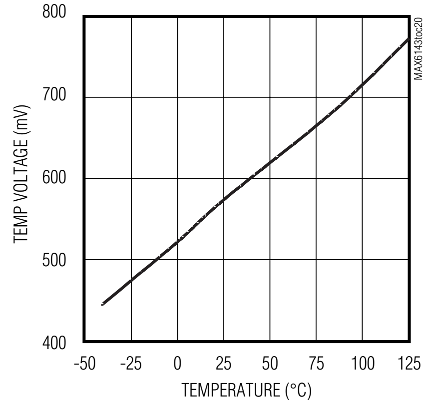
Typical Operating Characteristics (continued)

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

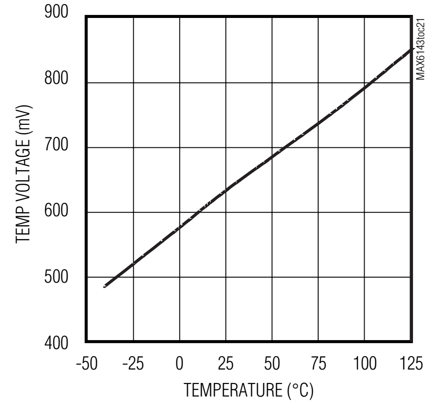
SHUTDOWN SUPPLY CURRENT vs. TEMPERATURE (V_{OUT} = 10V)



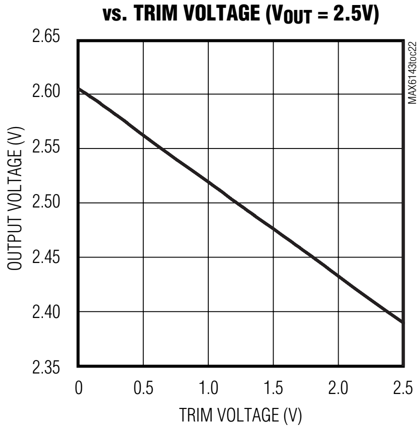
TEMP VOLTAGE vs. TEMPERATURE (V_{OUT} = 2.5V)



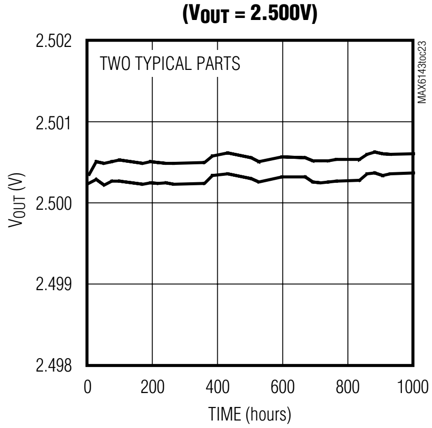
TEMP VOLTAGE vs. TEMPERATURE (V_{OUT} = 10V)



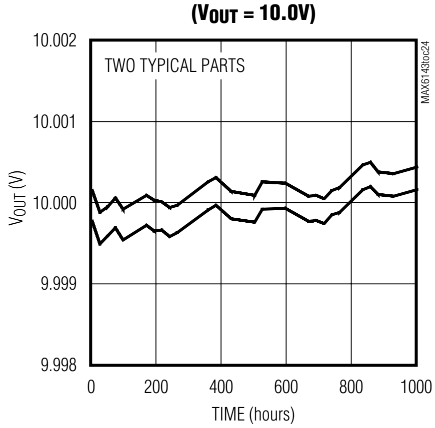
OUTPUT VOLTAGE vs. TRIM VOLTAGE (V_{OUT} = 2.5V)



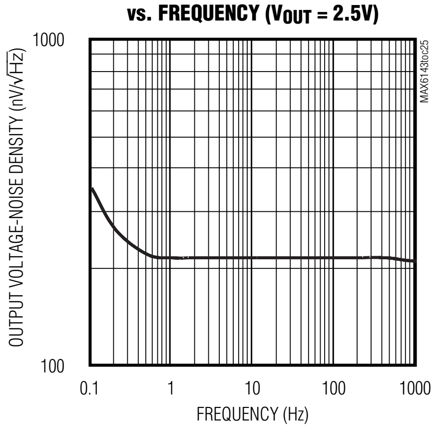
LONG-TERM STABILITY vs. TIME (V_{OUT} = 2.500V)



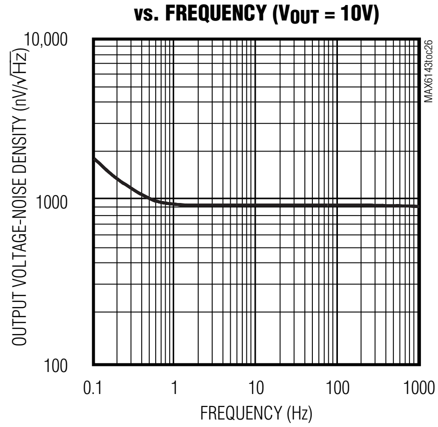
LONG-TERM STABILITY vs. TIME (V_{OUT} = 10.0V)



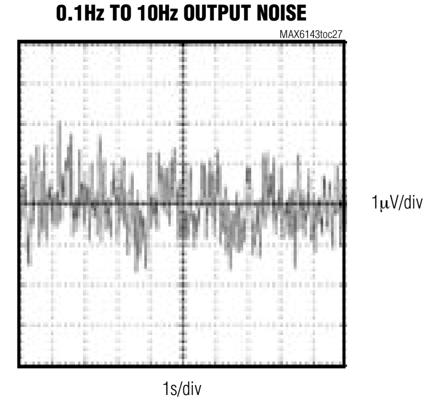
OUTPUT VOLTAGE-NOISE DENSITY vs. FREQUENCY (V_{OUT} = 2.5V)



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



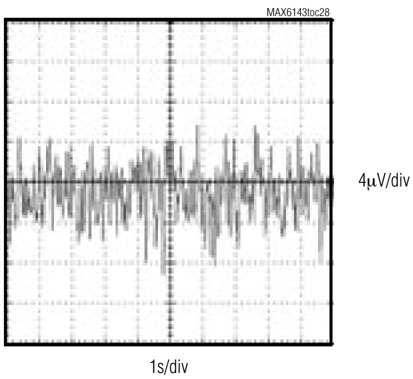
0.1Hz TO 10Hz OUTPUT NOISE



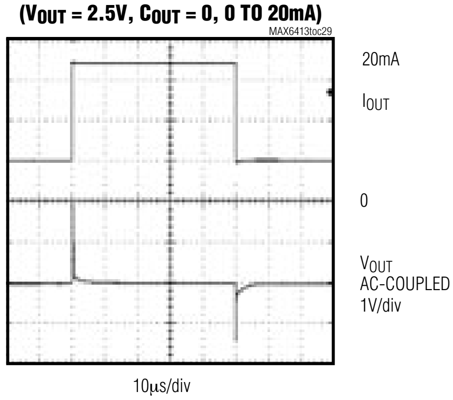
Typical Operating Characteristics (continued)

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

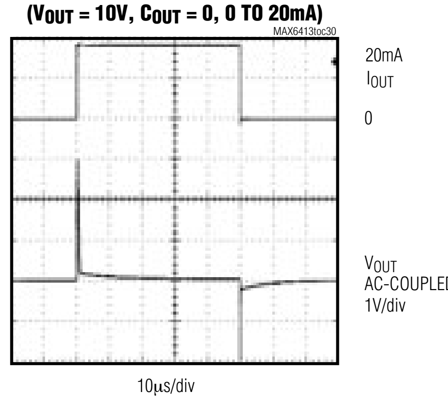
0.1Hz TO 10Hz OUTPUT NOISE



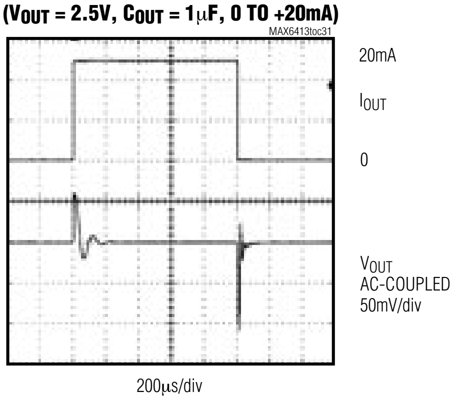
LOAD TRANSIENT (V_{OUT} = 2.5V, C_{OUT} = 0, 0 TO 20mA)



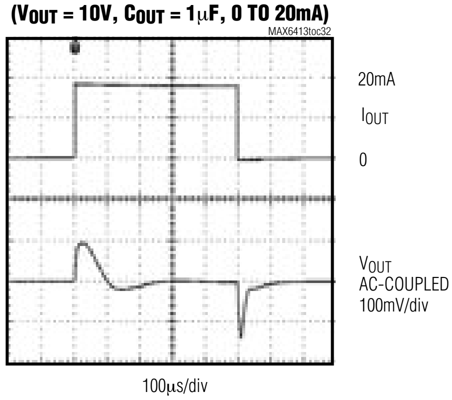
LOAD TRANSIENT (V_{OUT} = 10V, C_{OUT} = 0, 0 TO 20mA)



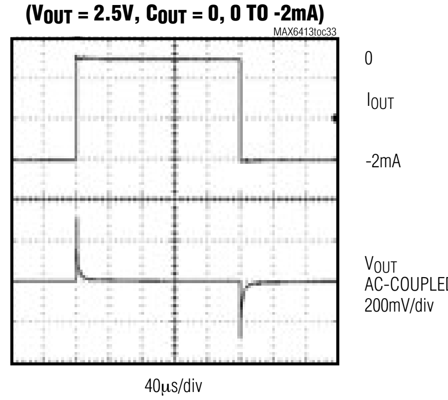
LOAD TRANSIENT (V_{OUT} = 2.5V, C_{OUT} = 1µF, 0 TO +20mA)



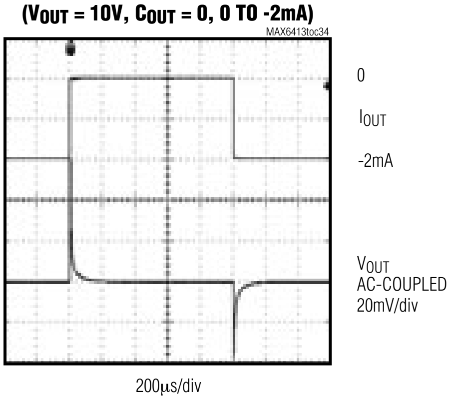
LOAD TRANSIENT (V_{OUT} = 10V, C_{OUT} = 1µF, 0 TO 20mA)



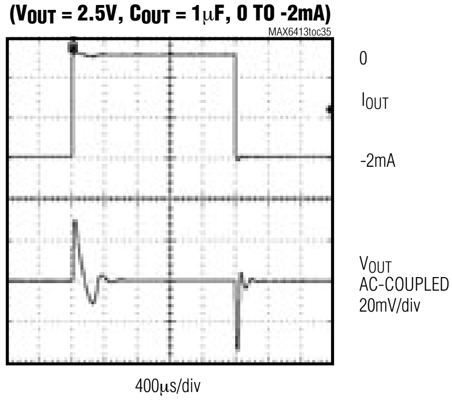
LOAD TRANSIENT (V_{OUT} = 2.5V, C_{OUT} = 0, 0 TO -2mA)



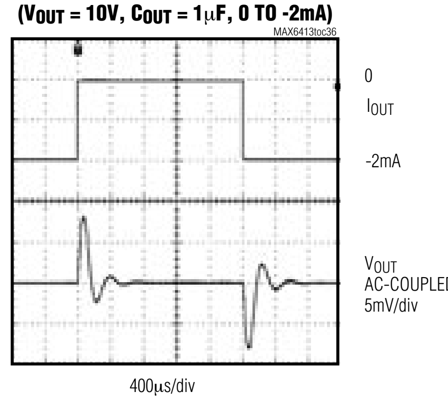
LOAD TRANSIENT (V_{OUT} = 10V, C_{OUT} = 0, 0 TO -2mA)



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



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

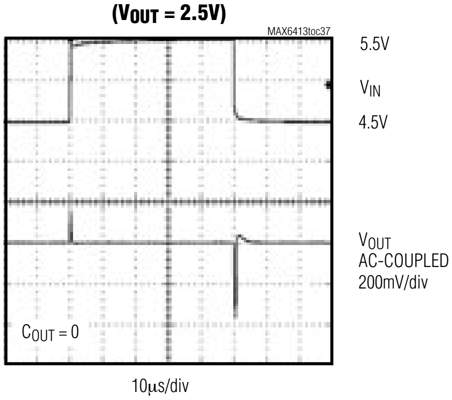


High-Precision Voltage Reference with Temperature Sensor

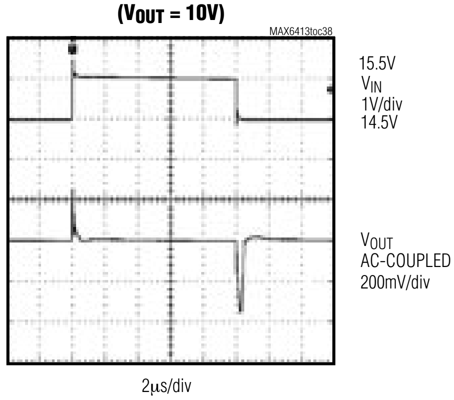
Typical Operating Characteristics (continued)

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

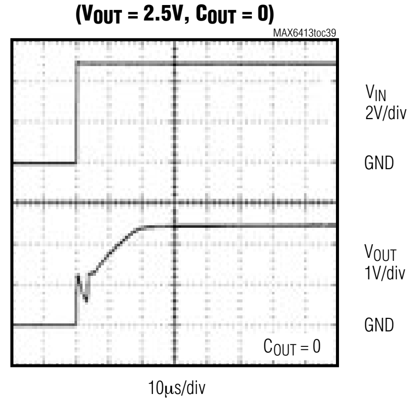
LINE TRANSIENT (V_{OUT} = 2.5V)



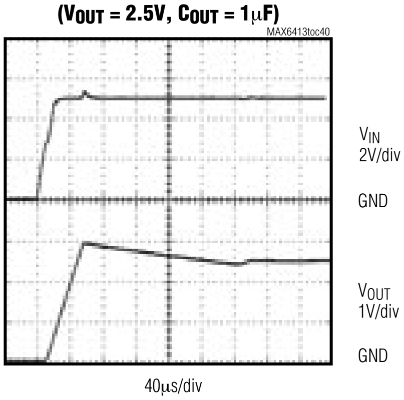
LINE TRANSIENT (V_{OUT} = 10V)



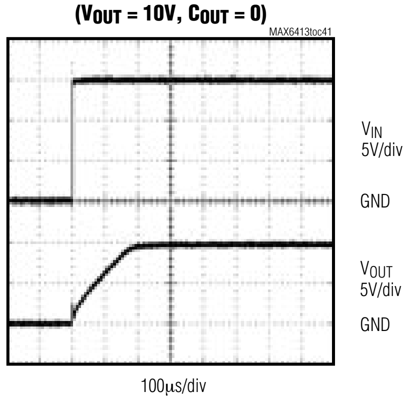
TURN-ON TRANSIENT (V_{OUT} = 2.5V, C_{OUT} = 0)



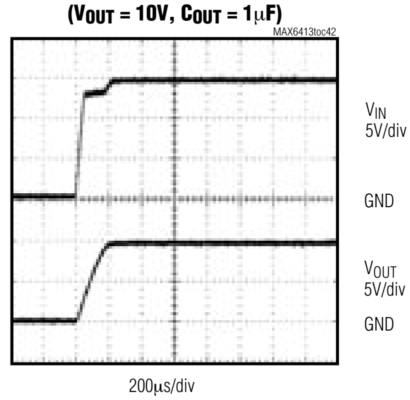
TURN-ON TRANSIENT (V_{OUT} = 2.5V, C_{OUT} = 1µF)



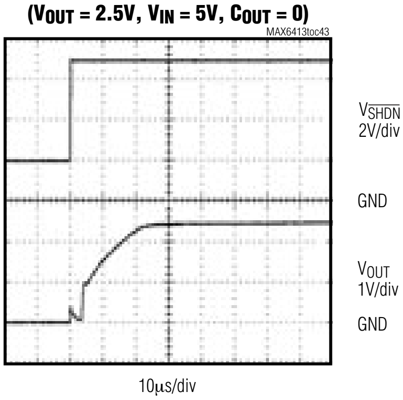
TURN-ON TRANSIENT (V_{OUT} = 10V, C_{OUT} = 0)



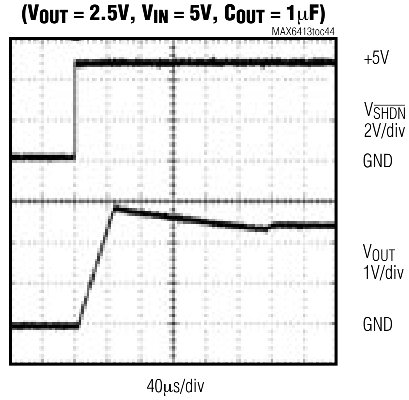
TURN-ON TRANSIENT (V_{OUT} = 10V, C_{OUT} = 1µF)



SHUTDOWN TRANSIENT (V_{OUT} = 2.5V, V_{IN} = 5V, C_{OUT} = 0)



SHUTDOWN TRANSIENT (V_{OUT} = 2.5V, V_{IN} = 5V, C_{OUT} = 1µF)

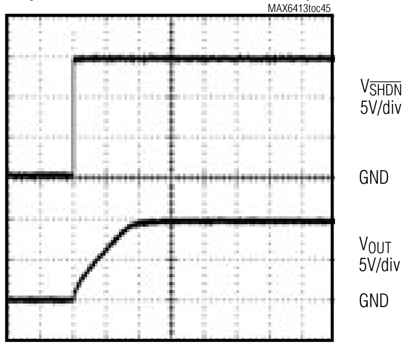


Typical Operating Characteristics (continued)

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

SHUTDOWN TRANSIENT
(V_{OUT} = 10V, V_{IN} = 15V, C_{OUT} = 0)

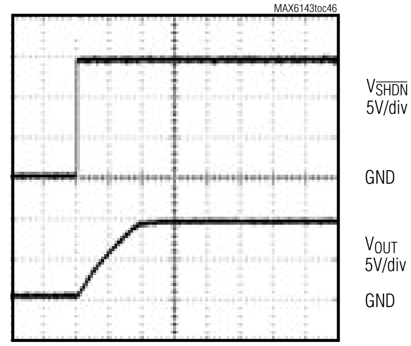
MAX6413toc45



100µs/div

SHUTDOWN TRANSIENT
(V_{OUT} = 10V, V_{IN} = 15V, C_{OUT} = 1µF)

MAX6143toc46



100µs/div

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	$\overline{\text{SHDN}}$	Active-Low Shutdown. Connect $\overline{\text{SHDN}}$ to IN for normal operation.

Detailed Description

The MAX6143 precision voltage reference provides 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 MAX6143 draws 340µA of supply current and sources 30mA or sinks 2mA of load current.

Trimming the Output Voltage

Trim the factory-preset output voltage on the MAX6143 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} = 0 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 MAX6143 provides 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 MAX6143 does not require an output capacitor for stability and is 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 device as possible for best performance.

Supply Current

The MAX6143 consumes 340µA of quiescent supply current. This improved efficiency reduces power dissipation and extends battery life.

Shutdown

The active-low shutdown feature reduces supply current to 0.01µA (typ), further extending battery life. Connect $\overline{SHDN}$ to GND to activate shutdown. Connect $\overline{SHDN}$ to IN for normal operation.

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 MAX6143 typically turns on and settles 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 at a 1µF load.

Short-Circuited Outputs

The MAX6143 features 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.

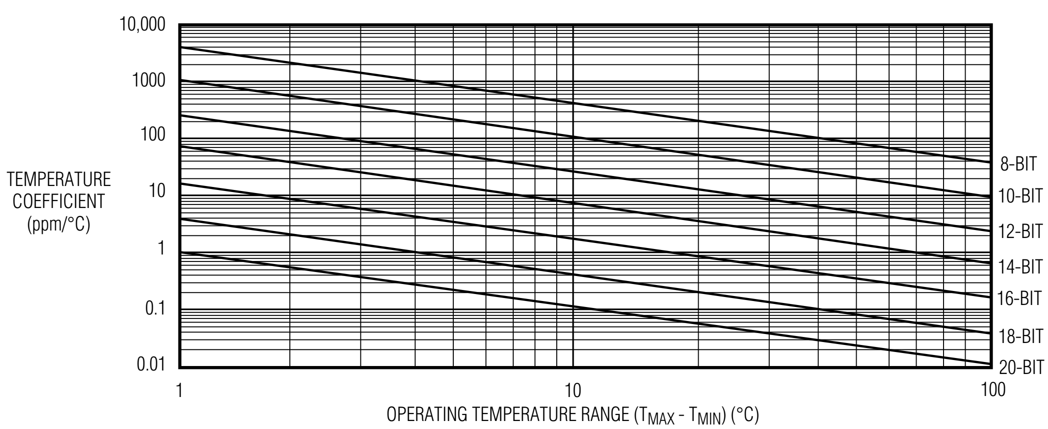


Figure 1. Temperature Coefficient vs. Operating Temperature Range for a 1 LSB Maximum Error

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.

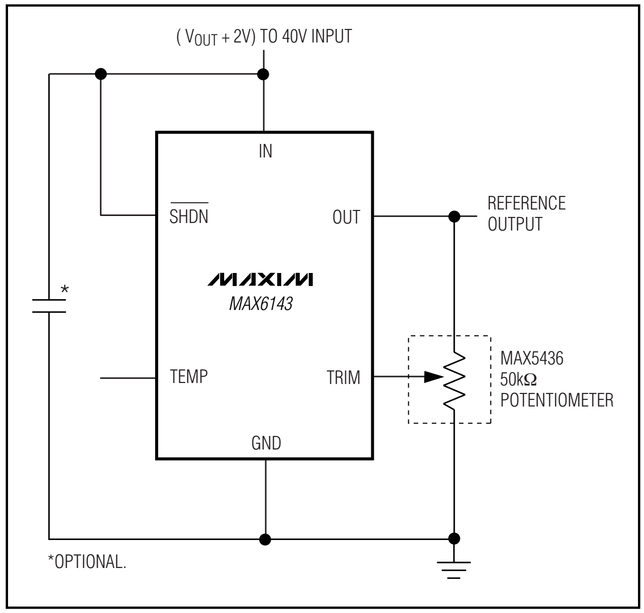
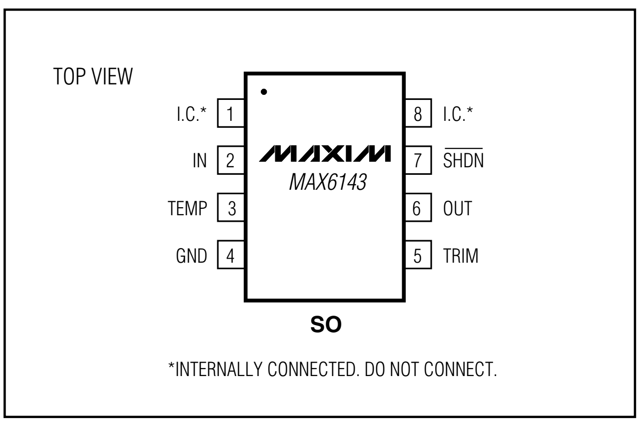


Figure 2. Applications Circuit Using the MAX5436 Potrntiometer

Pin Configuration



Chip Information

TRANSISTOR COUNT: 429

PROCESS: BiCMOS

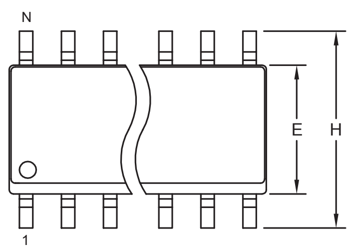
High-Precision Voltage Reference with Temperature Sensor

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to **www.maxim-ic.com/packages**.)

SOICN .EPS

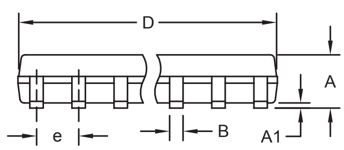
	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050 BSC		1.27 BSC	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
L	0.016	0.050	0.40	1.27



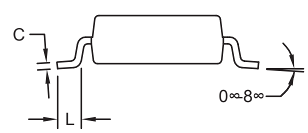
TOP VIEW

VARIATIONS:

	INCHES		MILLIMETERS			
DIM	MIN	MAX	MIN	MAX	N	MS012
D	0.189	0.197	4.80	5.00	8	AA
D	0.337	0.344	8.55	8.75	14	AB
D	0.386	0.394	9.80	10.00	16	AC



FRONT VIEW



SIDE VIEW

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. LEADS TO BE COPLANAR WITHIN 0.10mm (.004").
4. CONTROLLING DIMENSION: MILLIMETERS.
5. MEETS JEDEC MS012.
6. N = NUMBER OF PINS.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, .150" SOIC

APPROVAL | DOCUMENT CONTROL NO. 21-0041 | REV. B | 1/1

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