19-2647; Rev 2; 6/03

MAXIM

Ultra-High-Precision, Ultra-Low-Noise, Series Voltage Reference

MAX6126

General Description

The MAX6126 is an ultra-low-noise, high-precision, low-dropout voltage reference. This family of voltage references feature curvature-correction circuitry and high-stability, laser-trimmed, thin-film resistors that result in 3ppm/°C (max) temperature coefficients and an excellent ±0.02% (max) initial accuracy. The proprietary low-noise reference architecture produces a low flicker noise of 1.3µV$_{P-P}$ and wideband noise as low as 60nV/√Hz (2.048V output) without the increased supply current usually found in low-noise references. Improve wideband noise to 35nV/√Hz and AC power-supply rejection by adding a 0.1µF capacitor at the noise reduction pin. The MAX6126 series mode reference operates from a wide 2.7V to 12.6V supply voltage range and load-regulation specifications are guaranteed to be less than 0.025Ω for sink and source currents up to 10mA. These devices are available over the automotive temperature range of -40°C to +125°C.

The MAX6126 typically draws 380µA of supply current and is available in 2.048V, 2.500V, 3.000V, 4.096V, and 5.000V output voltages. These devices also feature dropout voltages as low as 200mV. Unlike conventional shunt-mode (two-terminal) references that waste supply current and require an external resistor, the MAX6126 offers supply current that is virtually independent of supply voltage and does not require an external resistor. The MAX6126 is stable with 0.1µF to 10µF of load capacitance.

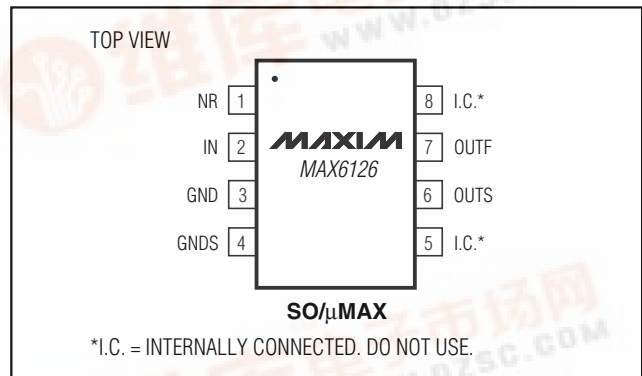The MAX6126 is available in the tiny 8-pin µMAX, as well as 8-pin SO packages.

Applications

High-Resolution A/D and D/A Converters

ATE Equipment

High-Accuracy Reference Standard

Precision Current Sources

Digital Voltmeters

High-Accuracy Industrial and Process Control

Features

♦ **Ultra-Low 1.3µV$_{P-P}$ Noise (0.1Hz to 10Hz, 2.048V Output)**

♦ **Ultra-Low 3ppm/°C (max) Temperature Coefficient**

♦ **±0.02% (max) Initial Accuracy**

♦ **Wide (V$_{OUT}$ + 200mV) to 12.6V Supply Voltage Range**

♦ **Low 200mV (max) Dropout Voltage**

♦ **380µA Quiescent Supply Current**

♦ **10mA Sink/Source-Current Capability**

♦ **Stable with C$_{LOAD}$ = 0.1µF to 10µF**

♦ **Low 20ppm/1000hr Long-Term Stability**

♦ **0.025Ω (max) Load Regulation**

♦ **20µV/V (max) Line Regulation**

♦ **Force and Sense Outputs for Remote Sensing**

Pin Configuration

TOP VIEW

NR	1	8	I.C.*
IN	2	7	OUTF
GND	3	6	OUTS
GNDS	4	5	I.C.*

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SO/µMAX

*I.C. = INTERNALLY CONNECTED. DO NOT USE.

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	OUTPUT VOLTAGE (V)	MAXIMUM INITIAL ACCURACY (%)	MAXIMUM TEMPCO (-40°C to +85°C) (ppm/°C)	TOP MARK
MAX6126AASA21	-40°C to +125°C	8 SO	2.048	0.02	3	—
MAX6126BASA21	-40°C to +125°C	8 SO	2.048	0.06	5	—
MAX6126AAUA21	-40°C to +125°C	8 µMAX	2.048	0.06	3	6126A21

Ordering Information continued at end of data sheet.

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For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at

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ABSOLUTE MAXIMUM RATINGS

(All voltages referenced to GND)
GNDS ....-0.3V to +0.3V
IN... -0.3V to +13V
OUTF, OUTS, NR........ -0.3V to the lesser of (V_{IN} + 0.3V) or +6V
Output Short Circuit to GND or IN 60s
Continuous Power Dissipation (T_A = +70°C)
   8-Pin µMAX (derate 4.5mW/°C above +70°C) 362mW
   8-Pin SO (derate 5.88mW/°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—MAX6126_21 (V_{OUT} = 2.048V)

(V_{IN} = 5V, C_{LOAD} = 0.1µF, I_{OUT} = 0, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
OUTPUT							
Output Voltage	V_{OUT}	T_A = +25°C			2.048		V
Output Voltage Accuracy		Referred to V_{OUT}, T_A = +25°C	A grade SO	-0.02		+0.02	%
			B grade SO	-0.06		+0.06	
			A grade µMAX	-0.06		+0.06	
			B grade µMAX	-0.1		+0.1	
Output Voltage Temperature Coefficient (Note 1)	TCV_{OUT}	T_A = -40°C to +85°C	A grade SO		0.5	3	ppm/°C
			B grade SO		1	5	
			A grade µMAX		1	3	
			B grade µMAX		2	7	
		T_A = -40°C to +125°C	A grade SO		1	5	
			B grade SO		2	10	
			A grade µMAX		2	5	
			B grade µMAX		3	12	
Line Regulation	$\Delta V_{OUT}/\Delta V_{IN}$	2.7V ≤ V_{IN} ≤ 12.6V	T_A = +25°C		2	20	µV/V
			T_A = -40°C to +125°C			40	
Load Regulation	$\Delta V_{OUT}/\Delta I_{OUT}$	Sourcing: 0 ≤ I_{OUT} ≤ 10mA			0.7	25	µV/mA
		Sinking: -10mA ≤ I_{OUT} ≤ 0			1.3	25	
OUT Short-Circuit Current	I_{SC}	Short to GND			160		mA
		Short to IN			20		
Thermal Hysteresis (Note 2)	$\Delta V_{OUT}/cycle$	SO			25		ppm
		µMAX			80		
Long-Term Stability	$\Delta V_{OUT}/time$	1000hr at T_A = +25°C	SO		20		ppm/ 1000hr
			µMAX		100		

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ELECTRICAL CHARACTERISTICS—MAX6126_21 (V$_{OUT}$ = 2.048V) (continued)

(V$_{IN}$ = 5V, C$_{LOAD}$ = 0.1µF, I$_{OUT}$ = 0, T$_A$ = T$_{MIN}$ to T$_{MAX}$, unless otherwise noted. Typical values are at T$_A$ = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
DYNAMIC CHARACTERISTICS							
Noise Voltage	e$_{OUT}$	f = 0.1Hz to 10Hz			1.3		µV$_{P-P}$
		f = 1kHz, C$_{NR}$ = 0			60		nV/√Hz
		f = 1kHz, C$_{NR}$ = 0.1µF			35		
Turn-On Settling Time	t$_R$	To V$_{OUT}$ = 0.01% of final value	C$_{NR}$ = 0		0.8		ms
			C$_{NR}$ = 0.1µF		20		
Capacitive-Load Stability Range	C$_{LOAD}$	No sustained oscillations			0.1 to 10		µF
INPUT							
Supply Voltage Range	V$_{IN}$	Guaranteed by line-regulation test		2.7		12.6	V
Quiescent Supply Current	I$_{IN}$	T$_A$ = +25°C			380	550	µA
		T$_A$ = -40°C to +125°C				725	

ELECTRICAL CHARACTERISTICS—MAX6126_25 (V$_{OUT}$ = 2.500V)

(V$_{IN}$ = 5V, C$_{LOAD}$ = 0.1µF, I$_{OUT}$ = 0, T$_A$ = T$_{MIN}$ to T$_{MAX}$, unless otherwise noted. Typical values are at T$_A$ = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
OUTPUT							
Output Voltage	V$_{OUT}$	T$_A$ = +25°C			2.500		V
Output Voltage Accuracy		Referred to V$_{OUT}$, T$_A$ = +25°C	A grade SO	-0.02		+0.02	%
			B grade SO	-0.06		+0.06	
			A grade µMAX	-0.06		+0.06	
			B grade µMAX	-0.1		+0.1	
Output Voltage Temperature Coefficient (Note 1)	TCV$_{OUT}$	T$_A$ = -40°C to +85°C	A grade SO		0.5	3	ppm/°C
			B grade SO		1	5	
			A grade µMAX		1	3	
			B grade µMAX		2	7	
		T$_A$ = -40°C to +125°C	A grade SO		1	5	
			B grade SO		2	10	
			A grade µMAX		2	5	
			B grade µMAX		3	12	
Line Regulation	ΔV$_{OUT}$/ ΔV$_{IN}$	2.7V ≤ V$_{IN}$ ≤ 12.6V	T$_A$ = +25°C		3	20	µV/V
			T$_A$ = -40°C to +125°C			40	
Load Regulation	ΔV$_{OUT}$/ ΔI$_{OUT}$	Sourcing: 0 ≤ I$_{OUT}$ ≤ 10mA			1	25	µV/mA
		Sinking: -10mA ≤ I$_{OUT}$ ≤ 0			1.8	25	

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ELECTRICAL CHARACTERISTICS—MAX6126_25 (V$_{OUT}$ = 2.500V) (continued)

(V$_{IN}$ = 5V, C$_{LOAD}$ = 0.1µF, I$_{OUT}$ = 0, T$_A$ = T$_{MIN}$ to T$_{MAX}$, unless otherwise noted. Typical values are at T$_A$ = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Dropout Voltage (Note 3)	V$_{IN}$ - V$_{OUT}$	ΔV$_{OUT}$ = 0.1%	I$_{OUT}$ = 5mA		0.06	0.2	V
			I$_{OUT}$ = 10mA		0.12	0.4	
OUT Short-Circuit Current	I$_{SC}$	Short to GND			160		mA
		Short to IN			20		
Thermal Hysteresis (Note 2)	ΔV$_{OUT}$/ cycle	SO			35		ppm
		µMAX			80		
Long-Term Stability	ΔV$_{OUT}$/ time	1000hr at T$_A$ = +25°C	SO		20		ppm/ 1000hr
			µMAX		100		
DYNAMIC CHARACTERISTICS							
Noise Voltage	e$_{OUT}$	f = 0.1Hz to 10Hz			1.45		µV$_{P-P}$
		f = 1kHz, C$_{NR}$ = 0			75		nV/√Hz
		f = 1kHz, C$_{NR}$ = 0.1µF			45		
Turn-On Settling Time	t$_R$	To V$_{OUT}$ = 0.01% of final value	C$_{NR}$ = 0		1		ms
			C$_{NR}$ = 0.1µF		20		
Capacitive-Load Stability Range	C$_{LOAD}$	No sustained oscillations			0.1 to 10		µF
INPUT							
Supply Voltage Range	V$_{IN}$	Guaranteed by line-regulation test		2.7		12.6	V
Quiescent Supply Current	I$_{IN}$	T$_A$ = +25°C			380	550	µA
		T$_A$ = -40°C to +125°C				725	

ELECTRICAL CHARACTERISTICS—MAX6126_30 (V$_{OUT}$ = 3.000V)

(V$_{IN}$ = 5V, C$_{LOAD}$ = 0.1µF, I$_{OUT}$ = 0, T$_A$ = T$_{MIN}$ to T$_{MAX}$, unless otherwise noted. Typical values are at T$_A$ = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
OUTPUT							
Output Voltage	V$_{OUT}$	T$_A$ = +25°C			3.000		V
Output Voltage Accuracy		Referred to V$_{OUT}$, T$_A$ = +25°C	A grade SO	-0.02		+0.02	%
			B grade SO	-0.06		+0.06	
			A grade µMAX	-0.06		+0.06	
			B grade µMAX	-0.1		+0.1	
Output Voltage Temperature Coefficient (Note 1)	TCV$_{OUT}$	T$_A$ = -40°C to +85°C	A grade SO		0.5	3	ppm/°C
			B grade SO		1	5	
			A grade µMAX		1	3	
			B grade µMAX		2	7	
		T$_A$ = -40°C to +125°C	A grade SO		1	5	
			B grade SO		2	10	
			A grade µMAX		2	5	
			B grade µMAX		3	12	

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ELECTRICAL CHARACTERISTICS—MAX6126_30 (V$_{OUT}$ = 3.000V) (continued)

(V$_{IN}$ = 5V, C$_{LOAD}$ = 0.1µF, I$_{OUT}$ = 0, T$_A$ = T$_{MIN}$ to T$_{MAX}$, unless otherwise noted. Typical values are at T$_A$ = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Line Regulation	ΔV$_{OUT}$/ ΔV$_{IN}$	3.2V ≤ V$_{IN}$ ≤ 12.6V	T$_A$ = +25°C		4	25	µV/V
			T$_A$ = -40°C to +125°C			50	
Load Regulation	ΔV$_{OUT}$/ ΔI$_{OUT}$	Sourcing: 0 ≤ I$_{OUT}$ ≤ 10mA			1.5	30	µV/mA
		Sinking: -10mA ≤ I$_{OUT}$ ≤ 0			2.8	30	
Dropout Voltage (Note 3)	V$_{IN}$ - V$_{OUT}$	ΔV$_{OUT}$ = 0.1%	I$_{OUT}$ = 5mA		0.06	0.2	V
			I$_{OUT}$ = 10mA		0.11	0.4	
OUT Short-Circuit Current	I$_{SC}$	Short to GND			160		mA
		Short to IN			20		
Thermal Hysteresis (Note 2)	ΔV$_{OUT}$/ cycle	SO			20		ppm
		µMAX			80		
Long-Term Stability	ΔV$_{OUT}$/ time	1000hr at T$_A$ = +25°C	SO		20		ppm/ 1000hr
			µMAX		100		
DYNAMIC CHARACTERISTICS							
Noise Voltage	e$_{OUT}$	f = 0.1Hz to 10Hz			1.75		µV$_{P-P}$
		f = 1kHz, C$_{NR}$ = 0			90		nV/√Hz
		f = 1kHz, C$_{NR}$ = 0.1µF			55		
Capacitive-Load Stability Range	C$_{LOAD}$	No sustained oscillations			0.1 to 10		µF
Turn-On Settling Time	t$_R$	To V$_{OUT}$ = 0.01% of final value	C$_{NR}$ = 0		1.2		ms
			C$_{NR}$ = 0.1µF		20		
INPUT							
Supply Voltage Range	V$_{IN}$	Guaranteed by line-regulation test		3.2		12.6	V
Quiescent Supply Current	I$_{IN}$	T$_A$ = +25°C			380	550	µA
		T$_A$ = -40°C to +125°C				725	

ELECTRICAL CHARACTERISTICS—MAX6126_41 (V$_{OUT}$ = 4.096V)

(V$_{IN}$ = 5V, C$_{LOAD}$ = 0.1µF, I$_{OUT}$ = 0, T$_A$ = T$_{MIN}$ to T$_{MAX}$, unless otherwise noted. Typical values are at T$_A$ = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
OUTPUT							
Output Voltage	V$_{OUT}$	T$_A$ = +25°C			4.096		V
Output Voltage Accuracy		Referred to V$_{OUT}$, T$_A$ = +25°C	A grade SO	-0.02		+0.02	%
			B grade SO	-0.06		+0.06	
			A grade µMAX	-0.06		+0.06	
			B grade µMAX	-0.1		+0.1	

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ELECTRICAL CHARACTERISTICS—MAX6126_41 (V_{OUT} = 4.096V) (continued)

(V_{IN} = 5V, C_{LOAD} = 0.1µF, I_{OUT} = 0, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Output Voltage Temperature Coefficient (Note 1)	TCV_{OUT}	T_A = -40°C to +85°C	A grade SO		0.5	3	ppm/°C
			B grade SO		1	5	
			A grade µMAX		1	3	
			B grade µMAX		2	7	
		T_A = -40°C to +125°C	A grade SO		1	5	
			B grade SO		2	10	
			A grade µMAX		2	5	
			B grade µMAX		3	12	
Line Regulation	$\Delta V_{OUT}/\Delta V_{IN}$	4.3V ≤ V_{IN} ≤ 12.6V	T_A = +25°C		4.5	30	µV/V
			T_A = -40°C to +125°C			60	
Load Regulation	$\Delta V_{OUT}/\Delta I_{OUT}$	Sourcing: 0 ≤ I_{OUT} ≤ 10mA			2	40	µV/mA
		Sinking: -10mA ≤ I_{OUT} ≤ 0			5	40	
Dropout Voltage (Note 3)	V_{IN} - V_{OUT}	ΔV_{OUT} = 0.1%	I_{OUT} = 5mA		0.05	0.2	V
			I_{OUT} = 10mA		0.1	0.4	
OUT Short-Circuit Current	I_{SC}	Short to GND			160		mA
		Short to IN			20		
Thermal Hysteresis (Note 2)	$\Delta V_{OUT}/$cycle	SO			20		ppm
		µMAX			80		
Long-Term Stability	$\Delta V_{OUT}/$time	1000hr at T_A = +25°C	SO		20		ppm/1000hr
			µMAX		100		
DYNAMIC CHARACTERISTICS							
Noise Voltage	e_{OUT}	f = 0.1Hz to 10Hz			2.4		µV$_{P-P}$
		f = 1kHz, C_{NR} = 0			120		nV/√Hz
		f = 1kHz, C_{NR} = 0.1µF			80		
Capacitive-Load Stability Range	C_{LOAD}	No sustained oscillations			0.1 to 10		µF
Turn-On Settling Time	t_R	To V_{OUT} = 0.01% of final value	C_{NR} = 0		1.6		ms
			C_{NR} = 0.1µF		20		
INPUT							
Supply Voltage Range	V_{IN}	Guaranteed by line-regulation test		4.3		12.6	V
Quiescent Supply Current	I_{IN}	T_A = +25°C			380	550	µA
		T_A = -40°C to +125°C				725	

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ELECTRICAL CHARACTERISTICS—MAX6126_50 (V_{OUT} = 5.000V)

(V_{IN} = 5.5V, C_{LOAD} = 0.1µF, I_{OUT} = 0, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

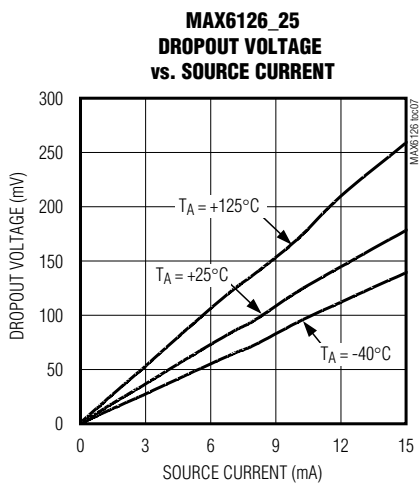| PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
OUTPUT							
Output Voltage	V_{OUT}	T_A = +25°C			5.000		V
Output Voltage Accuracy		T_A = +25°C	A grade SO	-0.02		+0.02	%
			B grade SO	-0.06		+0.06	
			A grade µMAX	-0.06		+0.06	
			B grade µMAX	-0.1		+0.1	
Output Voltage Temperature Coefficient (Note 1)	TCV_{OUT}	T_A = -40°C to +85°C	A grade SO		0.5	3	ppm/°C
			B grade SO		1	5	
			A grade µMAX		1	3	
			B grade µMAX		2	7	
		T_A = -40°C to +125°C	A grade SO		1	5	
			B grade SO		2	10	
			A grade µMAX		2	5	
			B grade µMAX		3	12	
Line Regulation	$\Delta V_{OUT}/\Delta V_{IN}$	5.2V ≤ V_{IN} ≤ 12.6V	T_A = +25°C		3	40	µV/V
			T_A = -40°C to +125°C			80	
Load Regulation	$\Delta V_{OUT}/\Delta I_{OUT}$	Sourcing: 0 ≤ I_{OUT} ≤ 10mA			2.5	50	µV/mA
		Sinking: -10mA ≤ I_{OUT} ≤ 0			6.5	50	
Dropout Voltage (Note 3)	V_{IN} - V_{OUT}	ΔV_{OUT} = 0.1%	I_{OUT} = 5mA		0.05	0.2	V
			I_{OUT} = 10mA		0.1	0.4	
OUT Short-Circuit Current	I_{SC}	Short to GND			160		mA
		Short to IN			20		
Thermal Hysteresis (Note 2)	$\Delta V_{OUT}/cycle$	SO			15		ppm
		µMAX			80		
Long-Term Stability	$\Delta V_{OUT}/time$	1000hr at T_A = +25°C	SO		20		ppm/1000hr
			µMAX		100		
DYNAMIC CHARACTERISTICS							
Noise Voltage	e_{OUT}	f = 0.1Hz to 10Hz			2.85		μV_{P-P}
		f = 1kHz, C_{NR} = 0			145		nV/√Hz
		f = 1kHz, C_{NR} = 0.1µF			95		
Capacitive-Load Stability Range	C_{LOAD}	No sustained oscillations			0.1 to 10		µF

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Ultra-High-Precision, Ultra-Low-Noise, Series Voltage Reference

ELECTRICAL CHARACTERISTICS—MAX6126_50 (V_{OUT} = 5.000V) (continued)

(V_{IN} = 5.5V, C_{LOAD} = 0.1μF, I_{OUT} = 0, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Turn-On Settling Time	t_R	To V_{OUT} = 0.01% of final value	C_{NR} = 0		2		ms
			C_{NR} = 0.1μF		20		
INPUT							
Supply Voltage Range	V_{IN}	Guaranteed by line-regulation test		5.2		12.6	V
Quiescent Supply Current	I_{IN}	T_A = +25°C			380	550	μA
		T_A = -40°C to +125°C				725	

Note 1: Temperature coefficient is measured by the "box" method, i.e., the maximum ΔV_{OUT} / V_{OUT} is divided by the maximum ΔT.
Note 2: Thermal hysteresis is defined as the change in +25°C output voltage before and after cycling the device from T_{MAX} to T_{MIN}.
Note 3: Dropout voltage is defined as the minimum differential voltage (V_{IN} - V_{OUT}) at which V_{OUT} decreases by 0.1% from its original value at V_{IN} = 5.0V (V_{IN} = 5.5V for V_{OUT} = 5.0V).

_____ Typical Operating Characteristics
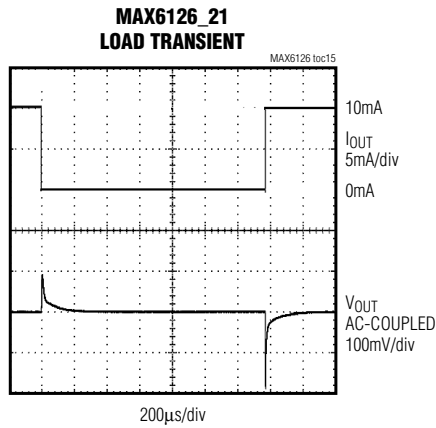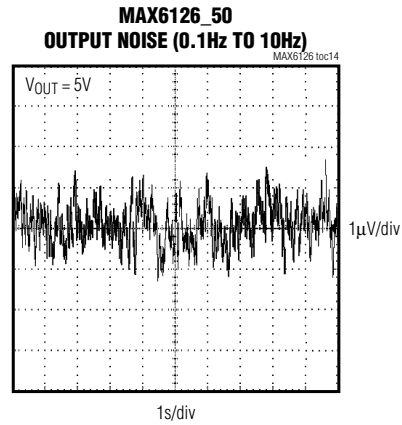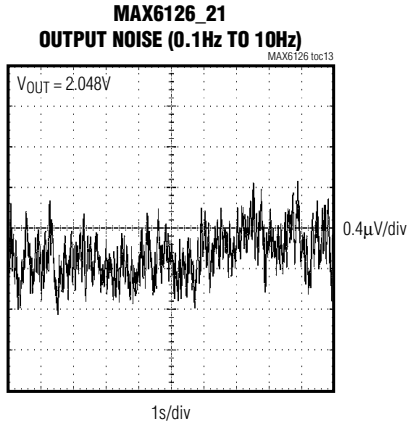
(V_{IN} = 5V for MAX6126_21/25/30/41, V_{IN} = 5.5V for MAX6126_50, C_{LOAD} = 0.1μF, I_{OUT} = 0, T_A = +25°C, unless otherwise specified.) (Note 5)
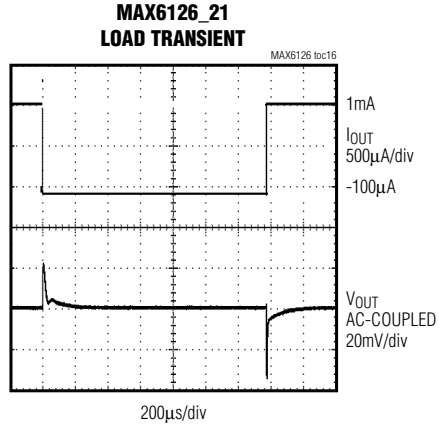
MAX6126A_21
OUTPUT VOLTAGE TEMPERATURE DRIFT
(V_{OUT} = 2.048V) (SO)

MAX6126A_21
OUTPUT VOLTAGE TEMPERATURE DRIFT
(V_{OUT} = 2.048V) (μMAX)

MAX6126A_50
OUTPUT VOLTAGE TEMPERATURE DRIFT
(V_{OUT} = 5.000V) (SO)
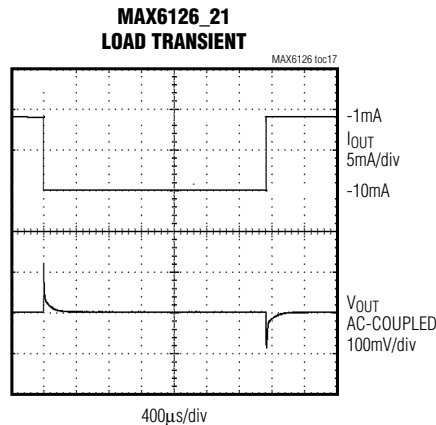
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Typical Operating Characteristics (continued)

(V_{IN} = 5V for MAX6126_21/25/30/41, V_{IN} = 5.5V for MAX6126_50, C_{LOAD} = 0.1µF, I_{OUT} = 0, T_A = +25°C, unless otherwise specified.)
(Note 5)

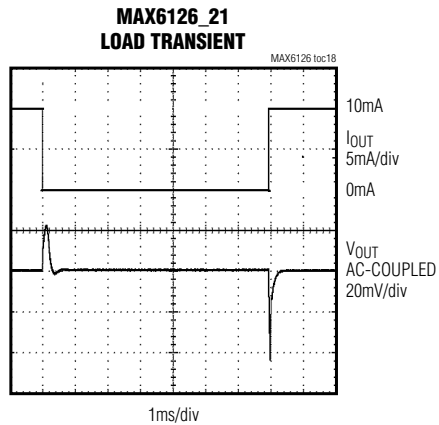**MAX6126A_50 OUTPUT VOLTAGE TEMPERATURE DRIFT (V_{OUT} = 5.000V) (µMAX)**

MAX6126_21 LOAD REGULATION

MAX6126_50 LOAD REGULATION

MAX6126_25 DROPOUT VOLTAGE vs. SOURCE CURRENT

MAX6126_50 DROPOUT VOLTAGE vs. SOURCE CURRENT

MAX6126_21 POWER-SUPPLY REJECTION RATIO vs. FREQUENCY

MAX6126_50 POWER-SUPPLY REJECTION RATIO vs. FREQUENCY

MAX6126_21 SUPPLY CURRENT vs. INPUT VOLTAGE
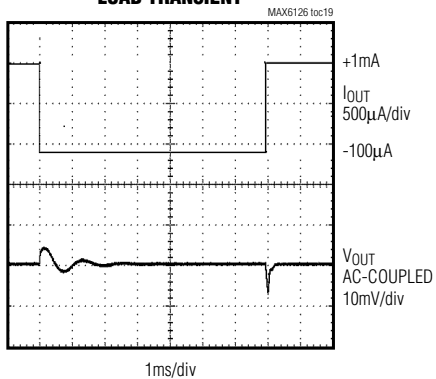
MAX6126_50 SUPPLY CURRENT vs. INPUT VOLTAGE
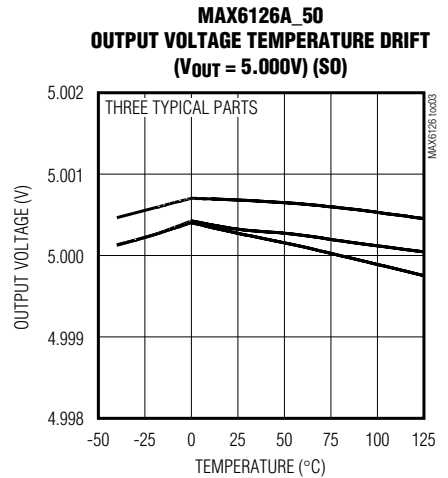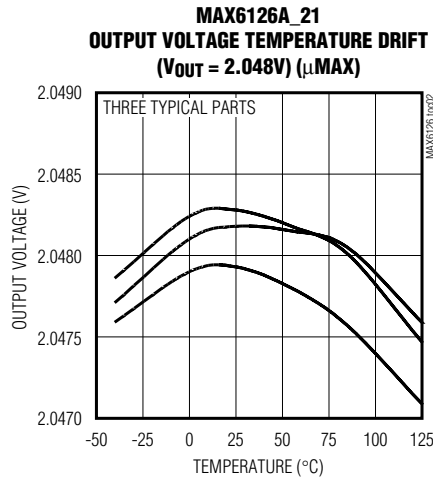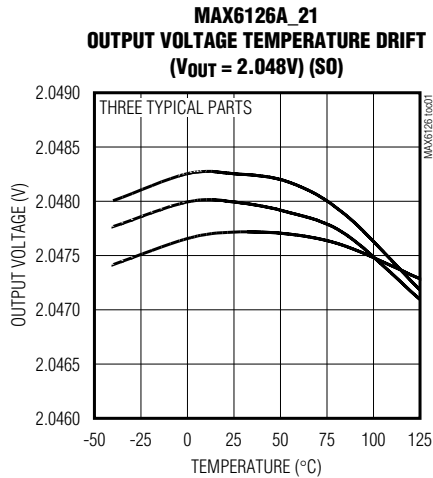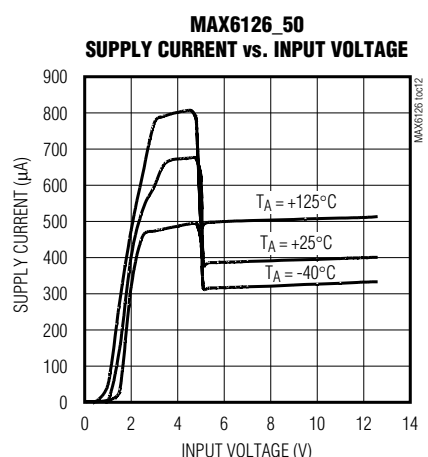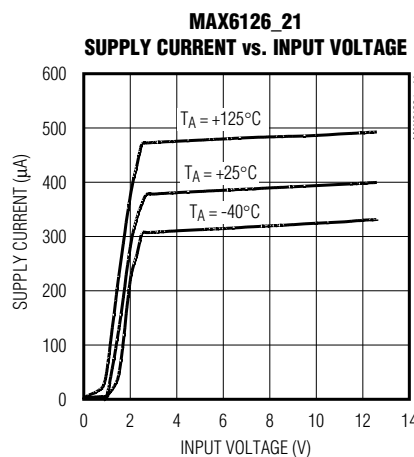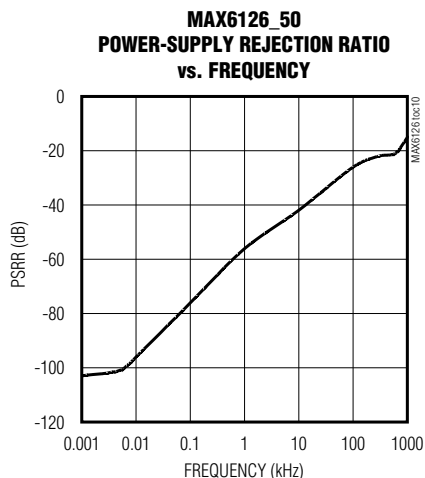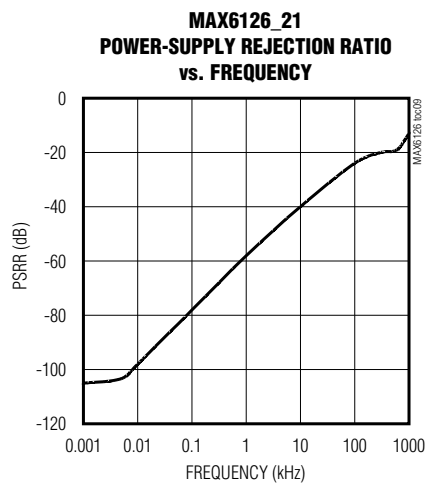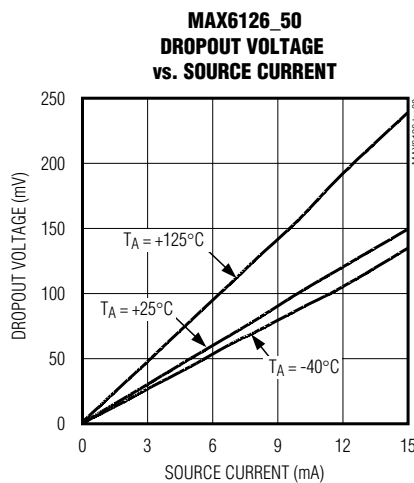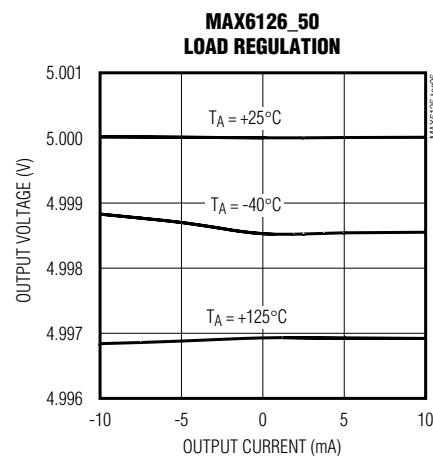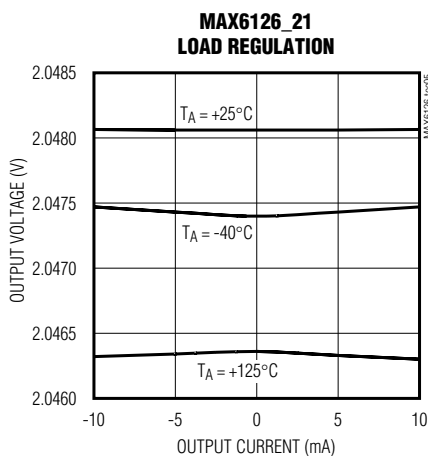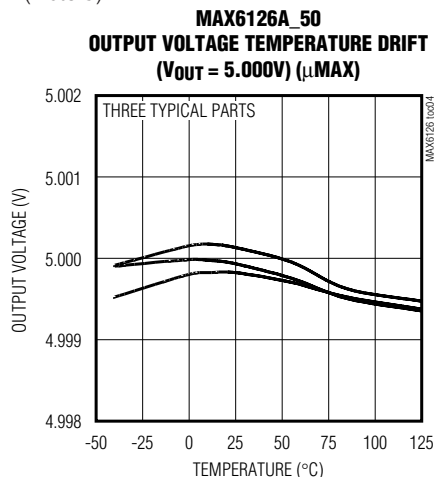
Ultra-High-Precision, Ultra-Low-Noise, Series Voltage Reference
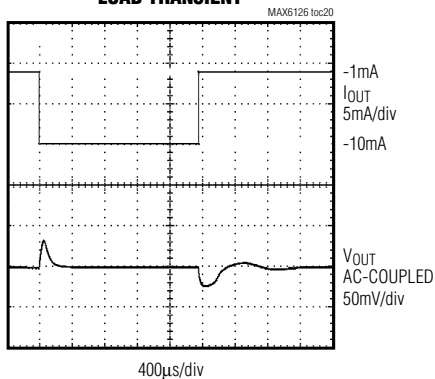
_____Typical Operating Characteristics (continued)

(V_{IN} = 5V for MAX6126_21/25/30/41, V_{IN} = 5.5V for MAX6126_50, C_{LOAD} = 0.1µF, I_{OUT} = 0, T_A = +25°C, unless otherwise specified.)
(Note 5)

MAX6126_21
OUTPUT NOISE (0.1Hz TO 10Hz)
MAX6126 toc13

V_{OUT} = 2.048V

0.4µV/div

1s/div

MAX6126_50
OUTPUT NOISE (0.1Hz TO 10Hz)
MAX6126 toc14

V_{OUT} = 5V

1µV/div

1s/div

MAX6126_21
LOAD TRANSIENT
MAX6126 toc15

10mA
I_{OUT}
5mA/div
0mA

V_{OUT}
AC-COUPLED
100mV/div

200µs/div

C_{LOAD} = 0.1µF I_{OUT} = 0 TO 10mA
V_{IN} = 5V V_{OUT} = 2.048V

MAX6126_21
LOAD TRANSIENT
MAX6126 toc16

1mA
I_{OUT}
500µA/div
-100µA

V_{OUT}
AC-COUPLED
20mV/div

200µs/div

C_{LOAD} = 0.1µF I_{OUT} = -100µA TO 1mA
V_{IN} = 5V V_{OUT} = 2.048V

MAX6126_21
LOAD TRANSIENT
MAX6126 toc17

-1mA
I_{OUT}
5mA/div
-10mA

V_{OUT}
AC-COUPLED
100mV/div

400µs/div

C_{LOAD} = 0.1µF I_{OUT} = -1mA TO -10mA
V_{IN} = 5V V_{OUT} = 2.048V

MAX6126_21
LOAD TRANSIENT
MAX6126 toc18

10mA
I_{OUT}
5mA/div
0mA

V_{OUT}
AC-COUPLED
20mV/div

1ms/div

C_{LOAD} = 10µF I_{OUT} = 0 TO 10mA
V_{IN} = 5V V_{OUT} = 2.048V

MAXIM

Typical Operating Characteristics (continued)

(V$_{IN}$ = 5V for MAX6126_21/25/30/41, V$_{IN}$ = 5.5V for MAX6126_50, C$_{LOAD}$ = 0.1µF, I$_{OUT}$ = 0, T$_A$ = +25°C, unless otherwise specified.) (Note 5)

MAX6126_21
LOAD TRANSIENT

MAX6126 toc19
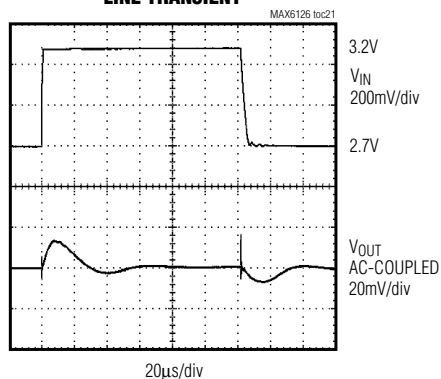
+1mA
I$_{OUT}$
500µA/div
-100µA

V$_{OUT}$
AC-COUPLED
10mV/div

1ms/div

C$_{LOAD}$ = 10µF   I$_{OUT}$ = -100µA TO 1mA
V$_{IN}$ = 5V   V$_{OUT}$ = 2.048V

MAX6126_21
LOAD TRANSIENT

MAX6126 toc20

-1mA
I$_{OUT}$
5mA/div
-10mA

V$_{OUT}$
AC-COUPLED
50mV/div

400µs/div

C$_{LOAD}$ = 10µF   I$_{OUT}$ = -1mA TO -10mA
V$_{IN}$ = 5V   V$_{OUT}$ = 2.048V

MAX6126_21
LINE TRANSIENT

MAX6126 toc21

3.2V
V$_{IN}$
200mV/div
2.7V

V$_{OUT}$
AC-COUPLED
20mV/div

20µs/div

V$_{OUT}$ = 2.048V   C$_{LOAD}$ = 0.1µF

MAX6126_50
LINE TRANSIENT

MAX6126 toc22

5.7V
V$_{IN}$
200mV/div
5.2V

V$_{OUT}$
AC-COUPLED
10mV/div

400µs/div

V$_{IN}$ = 5.2V TO 5.7V   C$_{LOAD}$ = 0.1µF
V$_{OUT}$ = 5V

MAX6126_21
TURN-ON TRANSIENT
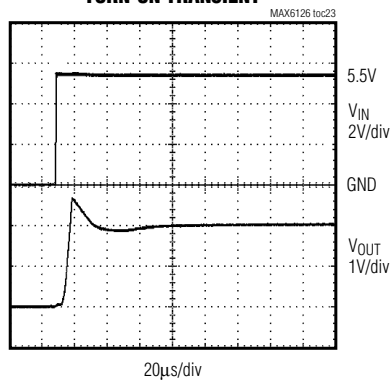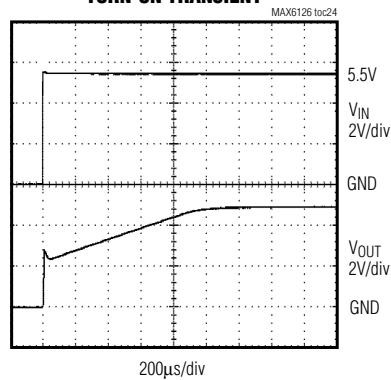
MAX6126 toc23

5.5V
V$_{IN}$
2V/div
GND

V$_{OUT}$
1V/div

20µs/div

C$_{LOAD}$ = 0.1µF
V$_{OUT}$ = 2.048V

MAX6126_50
TURN-ON TRANSIENT

MAX6126 toc24

5.5V
V$_{IN}$
2V/div
GND

V$_{OUT}$
2V/div
GND

200µs/div

C$_{LOAD}$ = 0.1µF
V$_{OUT}$ = 5V

MAX6126

MAX6126

Typical Operating Characteristics (continued)

(V_{IN} = 5V for MAX6126_21/25/30/41, V_{IN} = 5.5V for MAX6126_50, C_{LOAD} = 0.1µF, I_{OUT} = 0, T_A = +25°C, unless otherwise specified.) (Note 5)

MAX6126_21
TURN-ON TRANSIENT

C_{LOAD} = 10µF
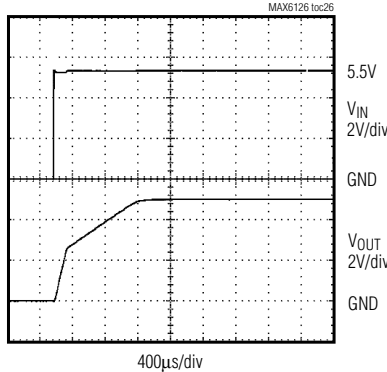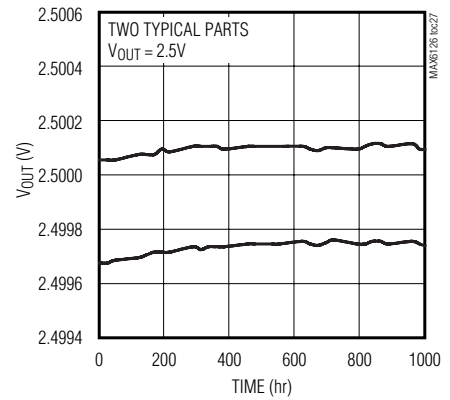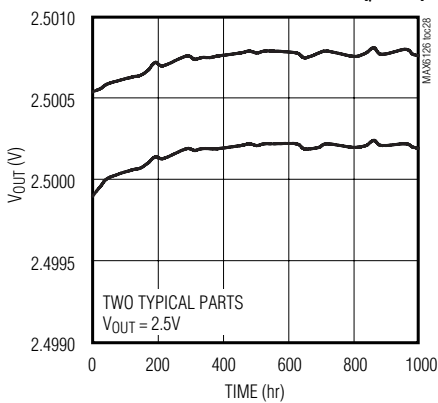V_{OUT} = 2.048V

MAX6126_50
TURN-ON TRANSIENT

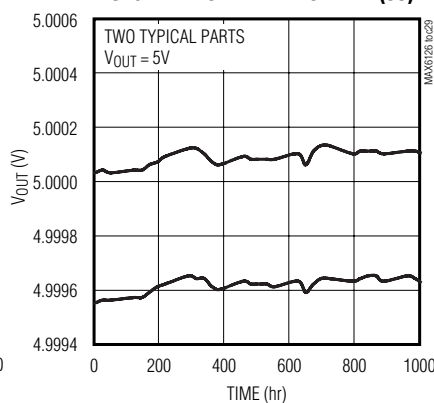C_{LOAD} = 10µF
V_{OUT} = 5V

MAX6126B_25
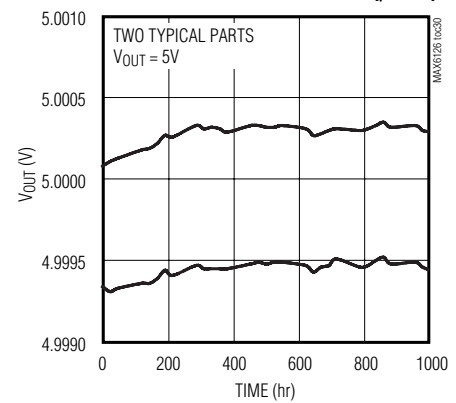**LONG-TERM STABILITY vs. TIME (SO)**

MAX6126B_25
LONG-TERM STABILITY vs. TIME (µMAX)

MAX6126B_50
LONG-TERM STABILITY vs. TIME (SO)

MAX6126B_50
LONG-TERM STABILITY vs. TIME (µMAX)

Note 5: Many of the MAX6126 *Typical Operating Characteristics* are extremely similar. The extremes of these characteristics are found in the MAX6126_21 (2.048V output) and the MAX6126_50 (5.000V output). The *Typical Operating Characteristics* of the remainder of the MAX6126 family typically lie between those two extremes and can be estimated based on their output voltages.

MAXIM

Pin Description

PIN	NAME	FUNCTION
1	NR	Noise Reduction. Connect a 0.1µF capacitor to improve wideband noise. Leave unconnected if not used (see Figure 1).
2	IN	Positive Power-Supply Input
3	GND	Ground
4	GNDS	Ground-Sense Connection. Connect to ground connection at load.
5, 8	I.C.	Internally Connected. **Do not connect anything to these pins.**
6	OUTS	Voltage Reference Sense Output
7	OUTF	Voltage Reference Force Output. Short OUTF to OUTS as close to the load as possible. Bypass OUTF with a capacitor (0.1µF to 10µF) to GND.

Figure 1. Noise-Reduction Capacitor

Detailed Description

Wideband Noise Reduction

To improve wideband noise and transient power-supply noise, add a 0.1µF capacitor to NR (Figure 1). Larger values do not improve noise appreciably. A 0.1µF NR capacitor reduces the noise from 60nV/$\sqrt{Hz}$ to 35nV/$\sqrt{Hz}$ for the 2.048V output. Noise in the power-supply input can affect output noise, but can be reduced by adding an optional bypass capacitor between IN and GND, as shown in the *Typical Operating Circuit*.

Output Bypassing

The MAX6126 requires an output capacitor between 0.1µF and 10µF. Locate the output capacitor as close to OUTF as possible. For applications driving switching capacitive loads or rapidly changing load currents, it is advantageous to use a 10µF capacitor in parallel with a 0.1µF capacitor. Larger capacitor values reduce transients on the reference output.

Supply Current

The quiescent supply current of the series-mode MAX6126 family is typically 380µA and is virtually independent of the supply voltage, with only a 2µA/V (max) variation with supply voltage.

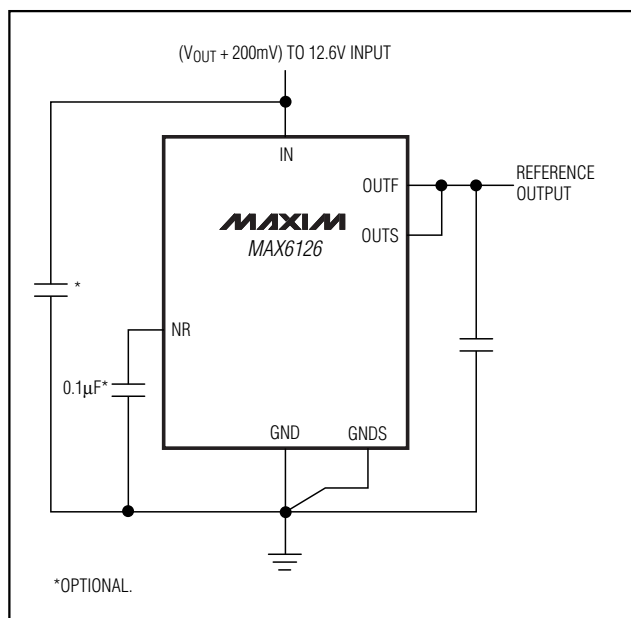When the supply voltage is below the minimum specified input voltage during turn-on, the device can draw up to 300µA beyond the nominal supply current. The input voltage source must be capable of providing this current to ensure reliable turn-on.

Thermal Hysteresis

Thermal hysteresis is the change of output voltage at T_A = +25°C before and after the device is cycled over its entire operating temperature range. The typical thermal hysteresis value is 20ppm (SO package).

Turn-On Time

These devices typically turn on and settle to within 0.1% of their final value in 200µs to 2ms depending on the device. The turn-on time can increase up to 4ms with the device operating at the minimum dropout voltage and the maximum load. A noise reduction capacitor of 0.1µF increases the turn-on time to 20ms.

Output Force and Sense

The MAX6126 provides independent connections for the power-circuit output (OUTF) supplying current into a load, and for the circuit input regulating the voltage applied to that load (OUTS). This configuration allows for the cancellation of the voltage drop on the lines connecting the MAX6126 and the load. When using the Kelvin connection made possible by the independent current and voltage connections, take the power connection to the load from OUTF, and bring a line from OUTS to join the line from OUTF, at the point where the voltage accu-

MAX6126

racy is needed. The MAX6126 has the same type of Kelvin connection to cancel drops in the ground return line. Connect the load to ground and bring a connection from GNDS to exactly the same point.

Applications Information

Precision Current Source

Figure 2 shows a typical circuit providing a precision current source. The OUTF output provides the bias current for the bipolar transistor. OUTS and GNDS sense the voltage across the resistor and adjust the current sourced by OUTF accordingly. For even higher precision, use a MOSFET to eliminate base current errors.

High-Resolution DAC and Reference from a Single Supply

Figure 3 shows a typical circuit providing the reference for a high-resolution, 16-bit MAX541 D/A converter.

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 4 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.
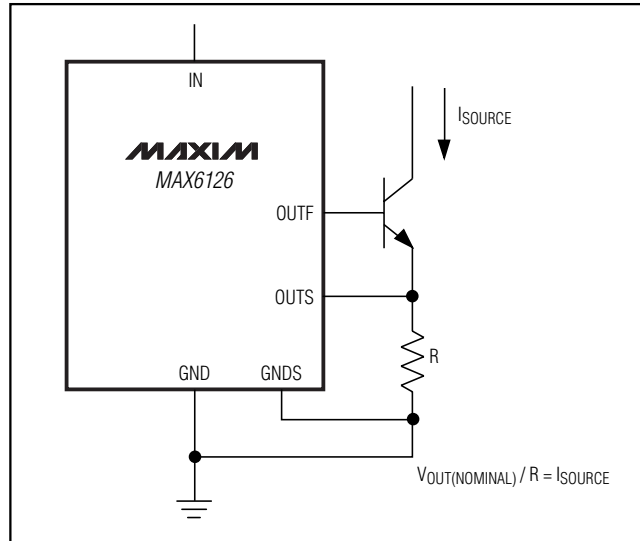

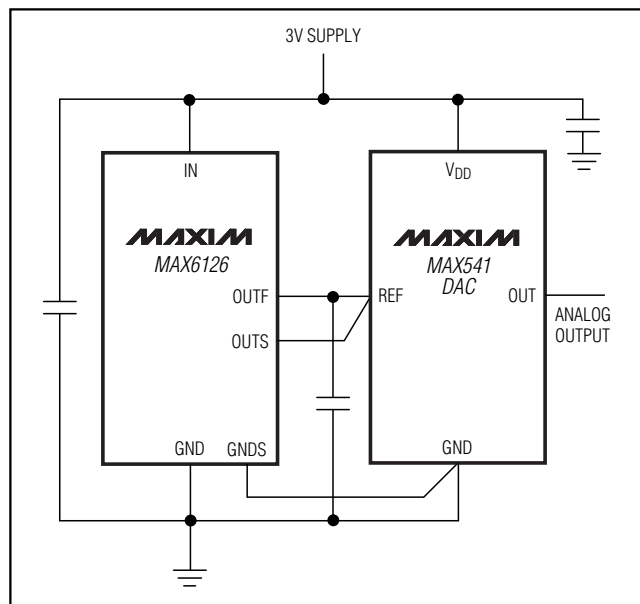Figure 2. Precision Current Source

Figure 3. 14-Bit High-Resolution DAC and Positive Reference from a Single 3V Supply

14 _____

MAXIM

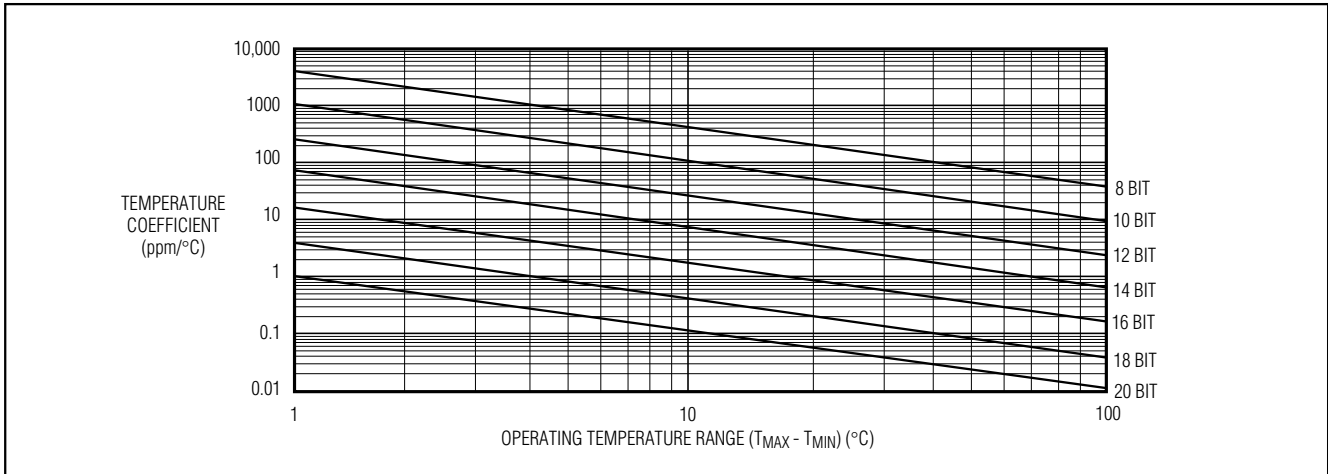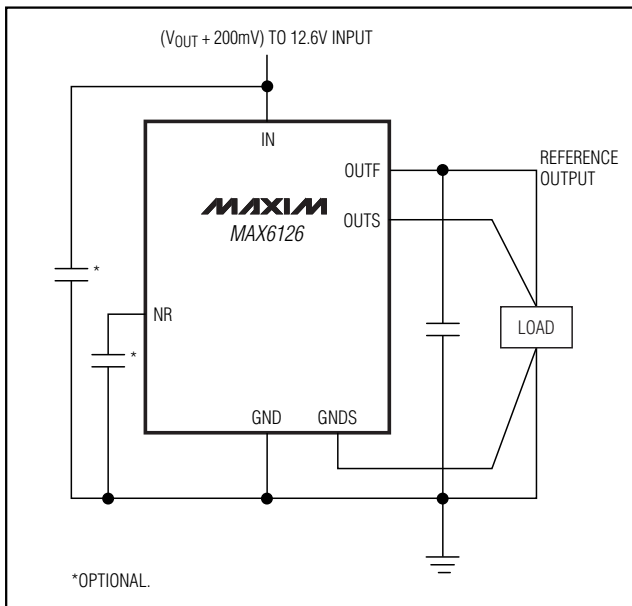# Ultra-High-Precision, Ultra-Low-Noise, Series Voltage Reference

Figure 4. Temperature Coefficient vs. Operating Temperature Range for a 1 LSB Maximum Error

_____Typical Operating Circuit

_____Chip Information

TRANSISTOR COUNT: 1171
PROCESS: BiCMOS

Ultra-High-Precision, Ultra-Low-Noise, Series Voltage Reference

__Ordering Information (continued)__

| PART	TEMP RANGE	PIN-PACKAGE	OUTPUT VOLTAGE (V)	MAXIMUM INITIAL ACCURACY (%)	MAXIMUM TEMPCO (-40°C to +85°C) (ppm/°C)	TOP MARK
MAX6126BAUA21	-40°C to +125°C	8 µMAX	2.048	0.1	7	6126B21
MAX6126AASA25	-40°C to +125°C	8 SO	2.500	0.02	3	—
MAX6126BASA25	-40°C to +125°C	8 SO	2.500	0.06	5	—
MAX6126AAUA25	-40°C to +125°C	8 µMAX	2.500	0.06	3	6126A25
MAX6126BAUA25	-40°C to +125°C	8 µMAX	2.500	0.1	7	6126B25
MAX6126AASA30	-40°C to +125°C	8 SO	3.000	0.02	3	—
MAX6126BASA30	-40°C to +125°C	8 SO	3.000	0.06	5	—
MAX6126AAUA30	-40°C to +125°C	8 µMAX	3.000	0.06	3	6126A30
MAX6126BAUA30	-40°C to +125°C	8 µMAX	3.000	0.1	7	6126B30
MAX6126AASA41	-40°C to +125°C	8 SO	4.096	0.02	3	—
MAX6126BASA41	-40°C to +125°C	8 SO	4.096	0.06	5	—
MAX6126AAUA41	-40°C to +125°C	8 µMAX	4.096	0.06	3	6126A41
MAX6126BAUA41	-40°C to +125°C	8 µMAX	4.096	0.1	7	6126B41
MAX6126AASA50	-40°C to +125°C	8 SO	5.000	0.02	3	—
MAX6126BASA50	-40°C to +125°C	8 SO	5.000	0.06	5	—
MAX6126AAUA50	-40°C to +125°C	8 µMAX	5.000	0.06	3	6126A50
MAX6126BAUA50	-40°C to +125°C	8 µMAX	5.000	0.1	7	6126B50

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Ultra-High-Precision, Ultra-Low-Noise, Series Voltage Reference

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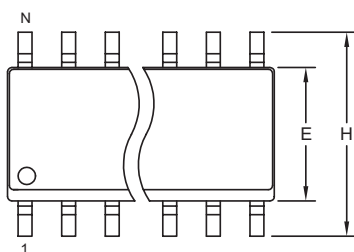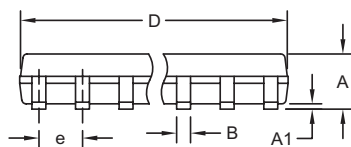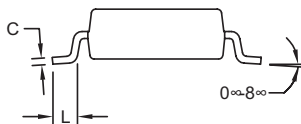
DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050 BSC		1.27 BSC	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
L	0.016	0.050	0.40	1.27

VARIATIONS:

DIM	INCHES		MILLIMETERS		N	MS012
	MIN	MAX	MIN	MAX		
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

TOP VIEW

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 /VI/IXI/VI

PROPRIETARY INFORMATION

TITLE:
PACKAGE OUTLINE, .150" SOIC

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0041	B	1⁄1

MAXIM

Ultra-High-Precision, Ultra-Low-Noise, Series Voltage Reference

Package Information (continued)

(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**.

8LUMAXD.EPS

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	-	0.043	-	1.10
A1	0.002	0.006	0.05	0.15
A2	0.030	0.037	0.75	0.95
b	0.010	0.014	0.25	0.36
c	0.005	0.007	0.13	0.18
D	0.116	0.120	2.95	3.05
e	0.0256 BSC		0.65 BSC	
E	0.116	0.120	2.95	3.05
H	0.188	0.198	4.78	5.03
L	0.016	0.026	0.41	0.66
α	0∞	6∞	0∞	6∞
S	0.0207 BSC		0.5250 BSC	

TOP VIEW

BOTTOM VIEW

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. CONTROLLING DIMENSION: MILLIMETERS.
4. MEETS JEDEC MO-187C-AA.

DALLAS SEMICONDUCTOR /\/\/\XI/\/\

PROPRIETARY INFORMATION

TITLE:
PACKAGE OUTLINE, 8L uMAX/uSOP

APPROVAL	DOCUMENT CONTROL NO. 21-0036	REV. J	1/1

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