*Click **here** for production status of specific part numbers.*

MAX6033

High-Precision, Low-Dropout SOT23 Series Voltage Reference

General Description

The MAX6033 ultra-high-precision series voltage reference features a low 7ppm/°C (max) temperature coefficient and a low dropout voltage (200mV, max). Low temperature drift and low noise make the MAX6033 ideal for use with high-resolution ADCs or DACs.

- This device uses bandgap technology for low-noise performance and excellent accuracy. Laser-trimmed, high-stability, thin-film resistors, and post-package trimming guarantee excellent initial accuracy (±0.04%, max). The MAX6033 consumes only 40μA of supply current and sources up to 15mA. Series mode references save system power and use minimal external components compared to two-terminal shunt references.
- The MAX6033 is available in the miniature 6-pin SOT23 package and is offered over the automotive temperature range (-40°C to +125°C).

Applications

- Precision Regulators
- A/D and D/A Converters
- Power Supplies
- Hard-Disk Drives
- High-Accuracy Industrial and Process Control
- Hand-Held Instruments

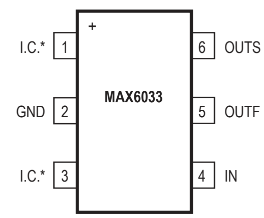
Typical Operating Circuit appears at end of data sheet.

Benefits and Features

- Stable Performance Over Temperature and Time Improves Accuracy
  - Ultra-Low Temperature Drift: 7ppm/°C (max)
  - ±0.04% Initial Accuracy
  - Stable with Capacitive Loads up to 100μF
  - Low $16\mu V_{P-P}$ Noise (0.1Hz to 10Hz) (2.5V Output)
  - Low 200mV Dropout Voltage
  - Excellent Load Regulation: 0.001mV/mA
- Low 40μA Quiescent Current Reduces System Power Consumption
- 2.7V to 12.6V Supply Voltage Eases Power Requirements

Pin Configuration

TOP VIEW



SOT23

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

Ordering Information/Selector Guide

PART	OUTPUT VOLTAGE (V)	TEMP COEFF (PPM/°C)	INITIAL ACCURACY (%)	TOP MARK
MAX6033AAUT25-T	2.500	10	0.04	ABDF
MAX6033BAUT25+T	2.500	15	0.20	+AAXL
MAX6033BAUT25-T	2.500	15	0.20	AAXL
MAX6033CAUT25-T	2.500	40	0.10	AAXH
MAX6033CAUT25+T	2.500	40	0.10	+AAXH

Ordering Information/Selector Guide continued on last page.

#Denotes a RoHS-compliant device that may include lead(Pb) that is exempt under the RoHS requirements.

T = Tape and reel.

**Denote as a future part.*

maxim integrated™

Absolute Maximum Ratings

IN to GND ....-0.3V to +13V
OUTF, OUTS to GND ....-0.3V to +6V
Continuous Power Dissipation (TA = +70°C)
6-Pin SOT23 (derate 7.40mW/°C above +70°C) ...595.20mW
Operating Temperature Range .... -40°C to +125°C
Storage Temperature Range .... -65°C to +150°C
Maximum Junction Temperature .... +150°C
Lead Temperature (soldering, 10s) .... +300°C
Soldering Temperature (reflow)
RoHS-Compliant Packages .... +245°C
Packages Containing Lead(Pb) .... +240°C

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

Package Information

6 SOT23

PACKAGE CODE	U6F+6
Outline Number	21-0058
Land Pattern Number	90-0175
Thermal Resistance, Single-Layer Board	
Junction to Ambient (θ_{JA})	185.50
Junction to Case (θ_{JC})	75
Thermal Resistance, Four-Layer Board	
Junction to Ambient (θ_{JA})	134.40
Junction to Case (θ_{JC})	39

RoHS SOT23-6

PACKAGE CODE	U6FH+6
Outline Number	—
Land Pattern Number	—
Thermal Resistance, Single-Layer Board	
Junction to Ambient (θ_{JA})	185.50
Junction to Case (θ_{JC})	75
Thermal Resistance, Four-Layer Board	
Junction to Ambient (θ_{JA})	134.40
Junction to Case (θ_{JC})	39

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—V_{OUT} = 2.500V

(V_{IN} = 5V, C_{OUT} = 0.1µF, I_{OUT} = 0A, T_A = T_{MIN} to T_{MAX}, unless otherwise specified. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Output Voltage	V_{OUT}	T_A = +25°C	MAX6033A	2.4990	2.5000	2.5010	V
			MAX6033B	2.4950	2.5000	2.5050	
			MAX6033C	2.4975	2.5000	2.5025	
Output-Voltage Accuracy		T_A = +25°C	MAX6033A	-0.04		+0.04	%
			MAX6033B	-0.2		+0.2	
			MAX6033C	-0.1		+0.1	
Output Voltage Temperature Coefficient	TCV_{OUT}	MAX6033A	T_A = -40°C to +85°C		1.5	7	ppm/°C
			T_A = -40°C to +125°C		2.5	10	
		MAX6033B	T_A = -40°C to +85°C		3	10	
			T_A = -40°C to +125°C		7	15	
		MAX6033C	T_A = -40°C to +85°C		6	20	
			T_A = -40°C to +125°C		10	40	
Input Voltage Range	V_{IN}	Inferred from line regulation specification		2.7		12.6	V
Line Regulation	$\Delta V_{OUT}/\Delta V_{IN}$	2.7V ≤ V_{IN} ≤ 12.6V	T_A = +25°C		3	25	µV/V
			T_A = -40°C to +125°C			50	
Load Regulation	$\Delta V_{OUT}/\Delta I_{OUT}$	-100µA ≤ I_{OUT} ≤ 15mA	T_A = +25°C		0.001	0.05	mV/mA
			T_A = -40°C to +125°C			0.1	
Dropout Voltage (Note 2)	V_{DO}	V_{OUT} = 0.1%, I_{OUT} = 1mA			0.02	0.2	V
		V_{OUT} = 0.1%, I_{OUT} = 10mA	T_A = -40°C to +85°C		0.3	0.4	
			T_A = -40°C to +125°C			0.5	
Quiescent Supply Current	I_{IN}	T_A = +25°C			40	60	µA
		T_A = -40°C to +85°C				75	
		T_A = -40°C to +125°C				85	
Output Short-Circuit Current	I_{SC}	V_{OUT} = 0V			90		mA
		V_{OUT} = V_{IN}			-2		
Output-Voltage Noise	en	0.1Hz ≤ f ≤ 10Hz			16		$µV_{P-P}$
		10Hz ≤ f ≤ 1kHz			12		$µV_{RMS}$
Turn-On Settling Time	t_{ON}	V_{OUT} settles to ±0.01% of final value			500		µs
Temperature Hysteresis		(Note 3)			150		ppm
Long-Term Stability		Δt = 1000hr			40		ppm

Electrical Characteristics—V_{OUT} = 3.000V

(V_{IN} = 5V, C_{OUT} = 0.1µF, I_{OUT} = 0A, T_A = T_{MIN} to T_{MAX}, unless otherwise specified. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Output Voltage	V_{OUT}	T_A = +25°C	MAX6033A	2.9988	3.0000	3.0012	V
			MAX6033B	2.9940	3.0000	3.0060	
			MAX6033C	2.9970	3.0000	3.0030	
Output-Voltage Accuracy		T_A = +25°C	MAX6033A	-0.04		+0.04	%
			MAX6033B	-0.2		+0.2	
			MAX6033C	-0.1		+0.1	
Output-Voltage Temperature Coefficient	TCV_{OUT}	MAX6033A	T_A = -40°C to +85°C		1.5	7	ppm/°C
			T_A = -40°C to +125°C		2.5	10	
		MAX6033B	T_A = -40°C to +85°C		3	10	
			T_A = -40°C to +125°C		7	15	
		MAX6033C	T_A = -40°C to +85°C		6	20	
			T_A = -40°C to +125°C		10	40	
Input Voltage Range	V_{IN}	Inferred from line regulation specification		3.2		12.6	V
Line Regulation	$\Delta V_{OUT}/\Delta V_{IN}$	3.2V ≤ V_{IN} ≤ 12.6V	T_A = +25°C		4	30	µV/V
			T_A = -40°C to +125°C			60	
Load Regulation	$\Delta V_{OUT}/\Delta I_{OUT}$	-100µA ≤ I_{OUT} ≤ 15mA	T_A = +25°C		0.002	0.06	mV/mA
			T_A = -40°C to +125°C			0.12	
Dropout Voltage (Note 2)	V_{DO}	ΔV_{OUT} = 0.1%	I_{OUT} = 1mA		0.02	0.2	V
			I_{OUT} = 10mA		0.2	0.4	
Quiescent Supply Current	I_{IN}	T_A = +25°C			40	60	µA
		T_A = -40°C to +85°C				75	
		T_A = -40°C to +125°C				85	
Output Short-Circuit Current	I_{SC}	V_{OUT} = 0V			90		mA
		V_{OUT} = V_{IN}			-2		
Output-Voltage Noise	en	0.1Hz ≤ f ≤ 10Hz			24		μV_{P-P}
		10Hz ≤ f ≤ 1kHz			15		μV_{RMS}
Turn-On Settling Time	t_{ON}	V_{OUT} settles to ±0.01% of final value			600		µs
Temperature Hysteresis		(Note 3)			150		ppm
Long-Term Stability		Δt = 1000hr			40		ppm

Electrical Characteristics—V_{OUT} = 4.096V

(V_{IN} = 5V, C_{OUT} = 0.1µF, I_{OUT} = 0A, T_A = T_{MIN} to T_{MAX}, unless otherwise specified. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Output Voltage	V_{OUT}	T_A = +25°C	MAX6033A	4.0943	4.0960	4.0977	V
			MAX6033B	4.0878	4.0960	4.1042	
			MAX6033C	4.0919	4.0960	4.1001	
Output-Voltage Accuracy		T_A = +25°C	MAX6033A	-0.04		+0.04	%
			MAX6033B	-0.2		+0.2	
			MAX6033C	-0.1		+0.1	
Output-Voltage Temperature Coefficient	TCV_{OUT}	MAX6033A	T_A = -40°C to +85°C		1.5	7	ppm/°C
			T_A = -40°C to +125°C		2.5	10	
		MAX6033B	T_A = -40°C to +85°C		3	10	
			T_A = -40°C to +125°C		7	15	
		MAX6033C	T_A = -40°C to +85°C		6	20	
			T_A = -40°C to +125°C		10	40	
Input-Voltage Range	V_{IN}	Inferred from line regulation specification		4.3		12.6	V
Line Regulation	$\Delta V_{OUT}/\Delta V_{IN}$	4.3V ≤ V_{IN} ≤ 12.6V	T_A = +25°C		6	30	µV/V
			T_A = -40°C to +125°C			60	
Load Regulation	$\Delta V_{OUT}/\Delta I_{OUT}$	-100µA ≤ I_{OUT} ≤ 15mA	T_A = +25°C		0.002	0.08	mV/mA
			T_A = -40°C to +125°C			0.15	
Dropout Voltage (Note 2)	V_{DO}	ΔV_{OUT} = 0.1%	I_{OUT} = 1mA		0.02	0.2	V
			I_{OUT} = 10mA		0.2	0.4	
Quiescent Supply Current	I_{IN}	T_A = +25°C			40	60	µA
		T_A = -40°C to +85°C				75	
		T_A = -40°C to +125°C				85	
Output Short-Circuit Current	I_{SC}	V_{OUT} = 0V			90		mA
		V_{OUT} = V_{IN}			-2		
Output-Voltage Noise	en	0.1Hz ≤ f ≤ 10Hz			32		μV_{P-P}
		10Hz ≤ f ≤ 1kHz			22		μV_{RMS}
Turn-On Settling Time	t_{ON}	V_{OUT} settles to ±0.01% of final value			800		µs
Temperature Hysteresis		(Note 3)			150		ppm
Long-Term Stability		∆t = 1000hr			40		ppm

Electrical Characteristics—V_{OUT} = 5.000V

(V_{IN} = 5.5V, C_{OUT} = 0.1µF, I_{OUT} = 0A, T_A = T_{MIN} to T_{MAX}, unless otherwise specified. Typical values are at T_A = +25°C.) (Note 1)

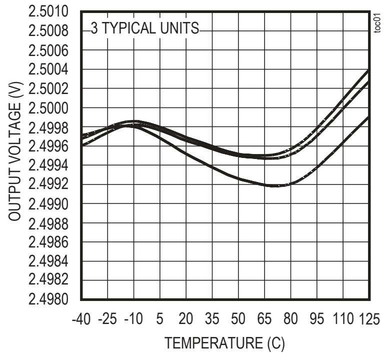
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Output Voltage	V_{OUT}	T_A = +25°C	MAX6033A	4.9980	5.000	5.0020	V
			MAX6033B	4.9900	5.000	5.0100	
			MAX6033C	4.9950	5.000	5.0050	
Output-Voltage Accuracy		T_A = +25°C	MAX6033A	-0.04		+0.04	%
			MAX6033B	-0.2		+0.2	
			MAX6033C	-0.1		+0.1	
Output-Voltage Temperature Coefficient	TCV_{OUT}	MAX6033A	T_A = -40°C to +85°C		1.5	7	ppm/°C
			T_A = -40°C to +125°C		2.5	10	
		MAX6033B	T_A = -40°C to +85°C		3	10	
			T_A = -40°C to +125°C		7	15	
		MAX6033C	T_A = -40°C to +85°C		6	20	
			T_A = -40°C to +125°C		10	40	
Input Voltage Range	V_{IN}	Inferred from line regulation specification		5.2		12.6	V
Line Regulation	$\Delta V_{OUT}/\Delta V_{IN}$	5.2V ≤ V_{IN} ≤ 12.6V	T_A = +25°C		7	50	µV/V
			T_A = -40°C to +125°C			100	
Load Regulation	$\Delta V_{OUT}/\Delta I_{OUT}$	-100µA ≤ I_{OUT} ≤ 15mA	T_A = +25°C		0.003	0.1	mV/mA
			T_A = -40°C to +125°C			0.2	
Dropout Voltage (Note 2)	V_{DO}	ΔV_{OUT} = 0.1%	I_{OUT} = 1mA		0.02	0.2	V
			I_{OUT} = 10mA		0.2	0.4	
Quiescent Supply Current	I_{IN}	T_A = +25°C			40	60	µA
		T_A = -40°C to +85°C				75	
		T_A = -40°C to +125°C				85	
Output Short-Circuit Current	I_{SC}	V_{OUT} = 0V			90		mA
		V_{OUT} = V_{IN}			-2		
Output-Voltage Noise	en	0.1Hz ≤ f ≤ 10Hz			40		$µV_{P-P}$
		10Hz ≤ f ≤ 1kHz			26		$µV_{RMS}$
Turn-On Settling Time	t_{ON}	V_{OUT} settles to ±0.01% of final value			1000		µs
Temperature Hysteresis		(Note 3)			150		ppm
Long-Term Stability		Δt = 1000hr			40		ppm

Note 1: MAX6033 is 100% production tested at T_A = +25°C and is guaranteed by design for T_A = T_{MIN} to T_{MAX} as specified.
Note 2: Dropout Voltage is the minimum input voltage at which V_{OUT} changes ≤ 0.1% from V_{OUT} at V_{IN} = 5V (V_{IN} = 5.5V to V_{OUT} = 5V).
Note 3: Temperature Hysteresis is defined as the change in +25°C output voltage before and after cycling the device from T_{MAX} to T_{MIN}.

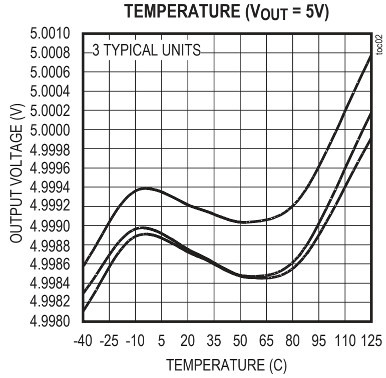
Typical Operating Characteristics

(V_{IN} = 5V, C_{OUT} = 0.1µF, I_{OUT} = 0A, T_A = +25°C, unless otherwise specified.) (Note 4)

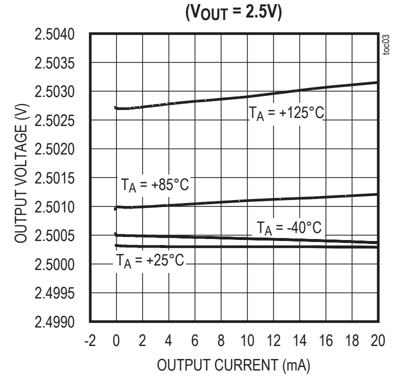
OUTPUT VOLTAGE vs. TEMPERATURE (V_{OUT} = 2.5V)



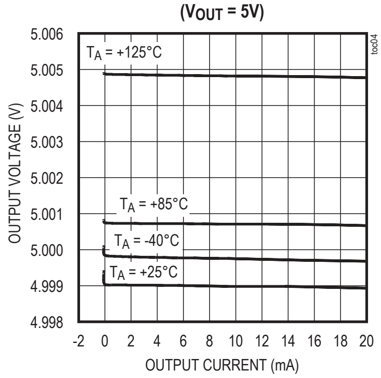
OUTPUT VOLTAGE vs. TEMPERATURE (V_{OUT} = 5V)



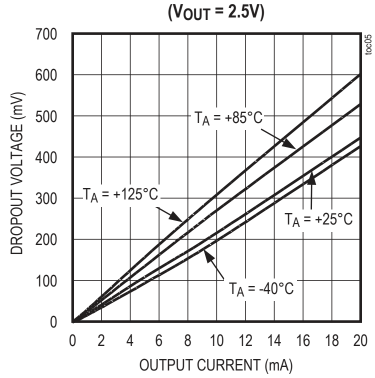
LOAD REGULATION (V_{OUT} = 2.5V)



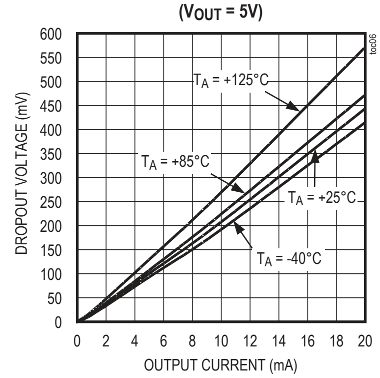
LOAD REGULATION (V_{OUT} = 5V)



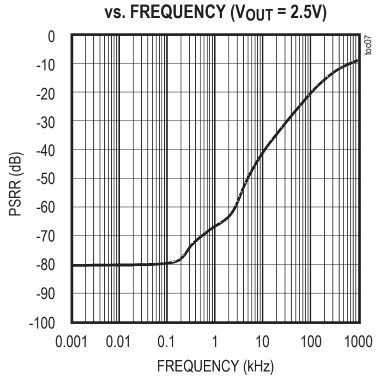
DROPOUT VOLTAGE vs. OUTPUT CURRENT (V_{OUT} = 2.5V)



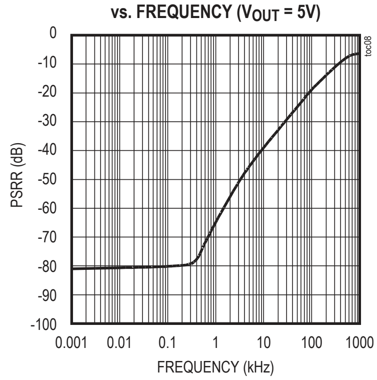
DROPOUT VOLTAGE vs. OUTPUT CURRENT (V_{OUT} = 5V)



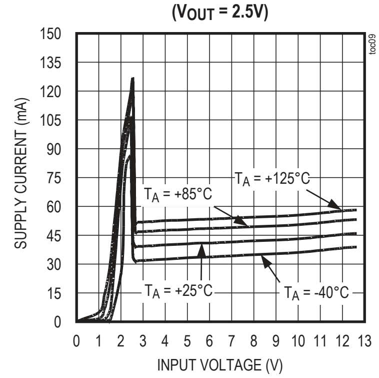
POWER-SUPPLY REJECTION RATIO vs. FREQUENCY (V_{OUT} = 2.5V)



POWER-SUPPLY REJECTION RATIO vs. FREQUENCY (V_{OUT} = 5V)

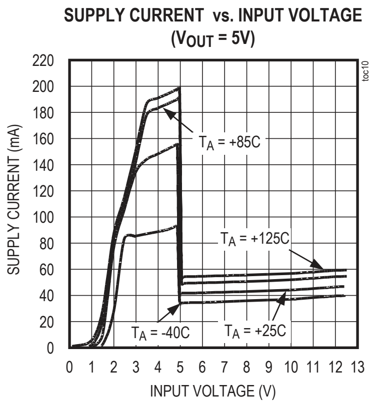


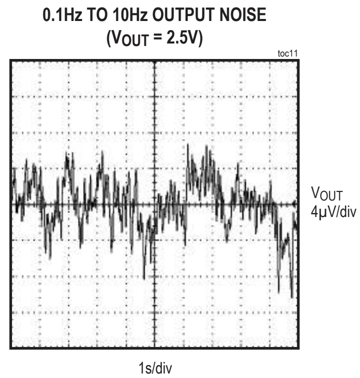
SUPPLY CURRENT vs. INPUT VOLTAGE (V_{OUT} = 2.5V)

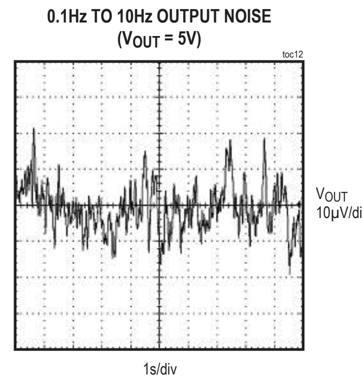


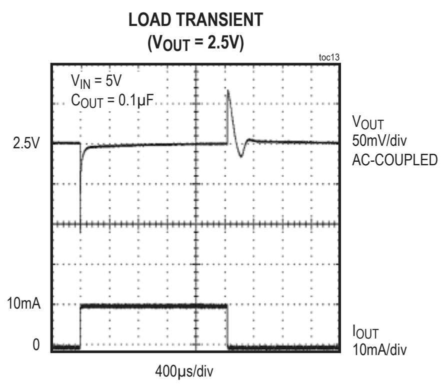
Typical Operating Characteristics (continued)

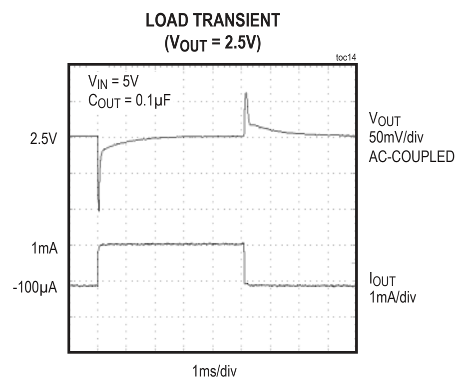
(V_{IN} = 5V, C_{OUT} = 0.1µF, I_{OUT} = 0A, T_A = +25°C, unless otherwise specified.) (Note 4)

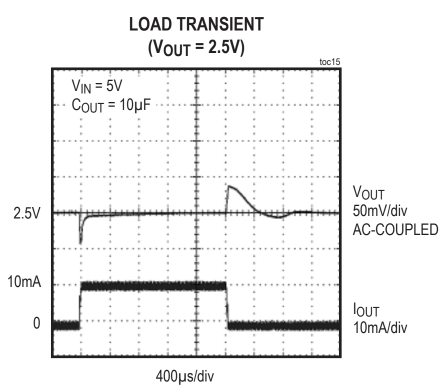


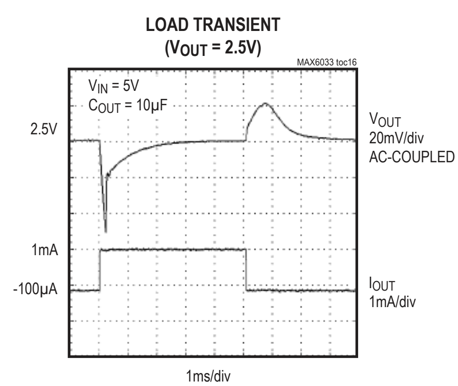








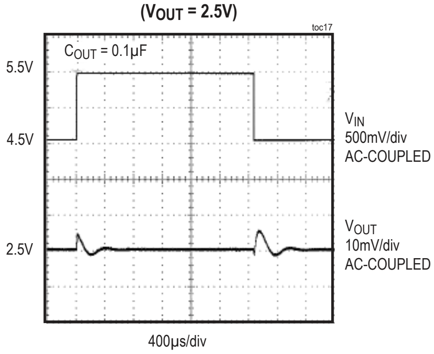




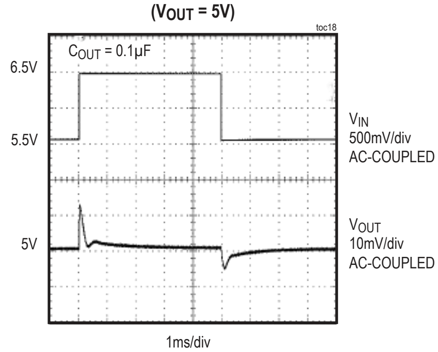
Typical Operating Characteristics (continued)

(V_{IN} = 5V, C_{OUT} = 0.1µF, I_{OUT} = 0A, T_A = +25°C, unless otherwise specified.) (Note 4)

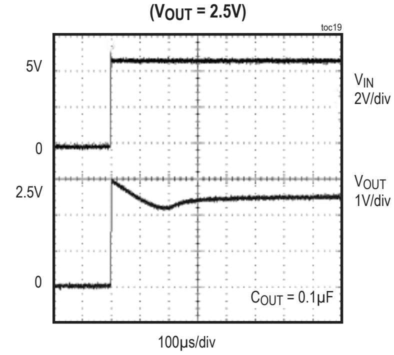
LINE TRANSIENT (V_{OUT} = 2.5V)



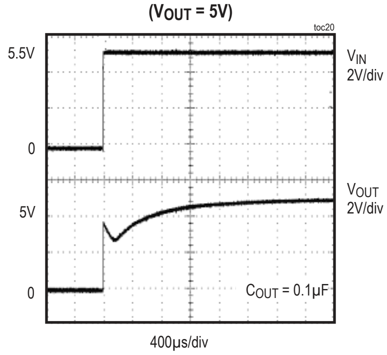
LINE TRANSIENT (V_{OUT} = 5V)



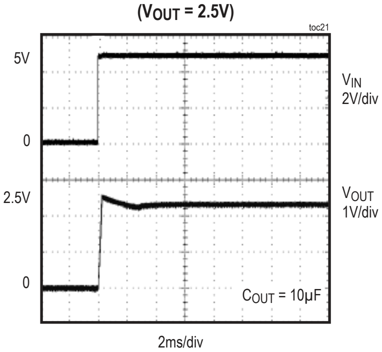
TURN-ON TRANSIENT (V_{OUT} = 2.5V)



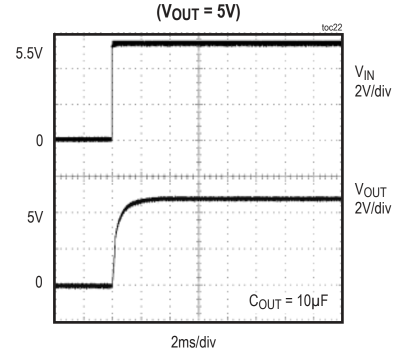
TURN-ON TRANSIENT (V_{OUT} = 5V)



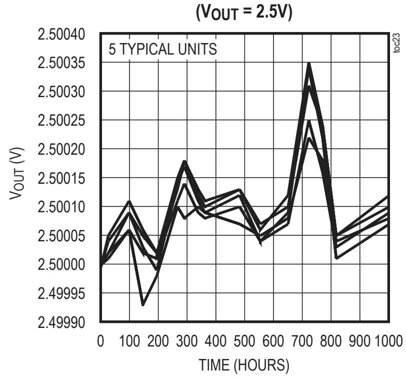
TURN-ON TRANSIENT (V_{OUT} = 2.5V)



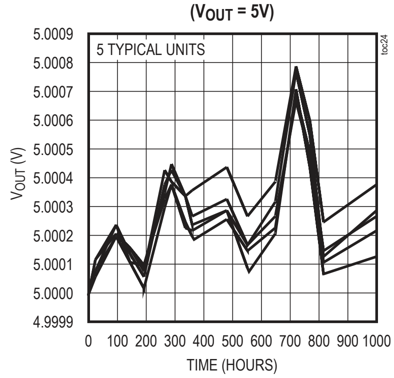
TURN-ON TRANSIENT (V_{OUT} = 5V)



LONG-TERM STABILITY vs. TIME (V_{OUT} = 2.5V)



LONG-TERM STABILITY vs. TIME (V_{OUT} = 5V)



Note 4: Many of the MAX6033 Typical Operating Characteristics are similar. The extremes of these characteristics are found in the MAX6033 (2.5V output) and the MAX6033 (5V output). The Typical Operating Characteristics of the remainder of the MAX6033 family typically lie between these two extremes and can be estimated based on their output voltages.

Pin Description

PIN	NAME	FUNCTION
1, 3	I.C.	Internally Connected. Do not connect externally.
2	GND	Ground
4	IN	Positive Power-Supply Input
5	OUTF	Voltage Reference Force Output. Short OUTF to OUTS as close to the device as possible. Bypass OUTF with 0.1µF (min) capacitor to GND.
6	OUTS	Voltage Reference Sense

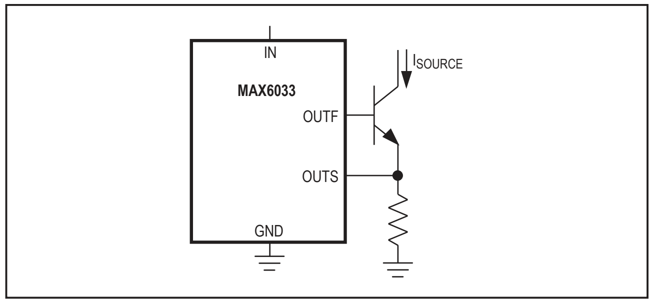


Figure 1. Precision Current Source

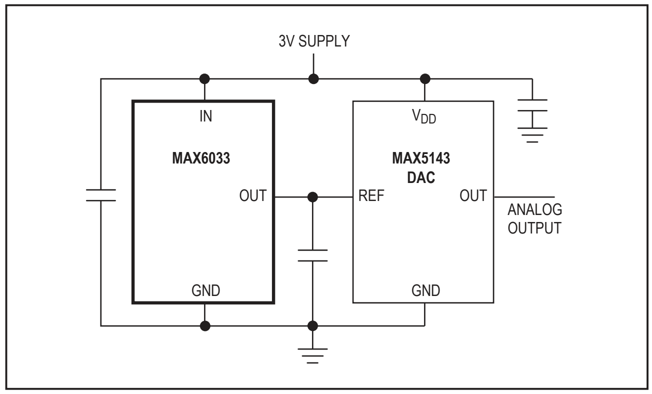


Figure 2. 14-Bit High-Resolution DAC and Positive Reference from a Single 3V Supply

Applications Information

Bypassing/Load 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 MAX6033 family requires a minimum output capacitance of 0.1µF for stability and is stable with capacitive loads (including the bypass capacitance) of 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.

Supply Current

The quiescent supply current of the MAX6033 series reference is typically 40µA and is virtually independent of the supply voltage. In the MAX6033 family, the load current is drawn from the input only when required, so supply current is not wasted and efficiency is maximized at all input voltages. This improved efficiency reduces power dissipation and extends battery life.

When the supply voltage is below the minimum-specified input voltage (as during turn-on), the devices can draw up to 150µA beyond the nominal supply current. The input voltage source must be capable of providing this current to ensure reliable turn-on.

Output-Voltage Hysteresis

Output voltage hysteresis is the change in the output voltage at T_A = +25°C before and after the device is cycled over its entire operating temperature range. Hysteresis is caused by differential package stress appearing across the bandgap core transistors. The typical temperature hysteresis value is 150ppm.

Turn-On Time

These devices typically turn on and settle to within 0.01% of their final value in >1µs. The turn-on time can increase up to 2ms with the device operating at the minimum dropout voltage and the maximum load.

Precision Current Source

Figure 1 shows a typical circuit providing a precision current source. The OUTF output provides the bias current for the bipolar transistor. OUTS senses the voltage across the resistor and adjusts the current sourced by OUTF accordingly.

High-Resolution DAC and Reference from Single Supply

Figure 2 shows a typical circuit providing both the power supply and reference for a high-resolution DAC. A MAX6033 with 2.5V output provides the reference voltage for the DAC.

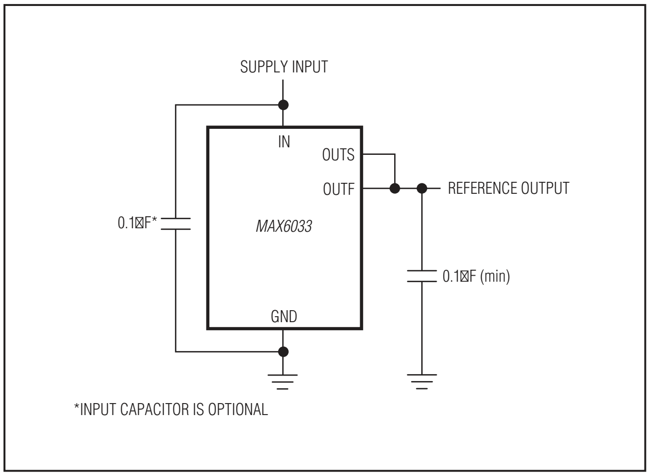
Ordering Information/Selector Guide (continued)

PART	OUTPUT VOLTAGE (V)	TEMP COEFF (PPM/°C)	INITIAL ACCURACY (%)	TOP MARK
MAX6033AAUT30-T	3.000	10	0.04	ABDG
MAX6033BAUT30+T	3.000	15	0.20	+AAXM
MAX6033BAUT30-T	3.000	15	0.20	AAXM
MAX6033BAUT30+T	3.000	15	0.20	+AAXM
MAX6033CAUT30-T	3.000	40	0.10	AAXI
MAX6033CAUT30+T	3.000	40	0.10	+AAXI
MAX6033AAUT41-T	4.096	10	0.04	ABDH
MAX6033BAUT41+T	4.096	15	0.20	+AAXN
MAX6033BAUT41-T	4.096	15	0.20	AAXN
MAX6033CAUT41-T	4.096	40	0.10	AAXJ
MAX6033CAUT41+T	4.096	40	0.10	+AAXJ
MAX6033AAUT50-T	5.000	10	0.04	ABDI
MAX6033BAUT50+T	5.000	15	0.20	+AAXO
MAX6033BAUT50-T	5.000	15	0.20	AAXO
MAX6033CAUT50-T	5.000	40	0.10	AAXK
MAX6033CAUT50+T	5.000	40	0.10	+AAXK

#Denotes a RoHS-compliant device that may include lead(Pb) that is exempt under the RoHS requirements.

T = Tape and reel.

Typical Operating Circuit



Chip Information

PROCESS: BiCMOS

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
2	6/03	Various changes	—
3	3/12	Replaced *Ordering Information* table/Selector Guide, updated packaging information	1, 10
4	2/19	Updated *Ordering Information*, *Absolute Maximum Ratings*, and *Package Thermal Characteristics*	1, 2, 10
5	3/19	Updated *Ordering Information*	1, 11
6	8/19	Updated *Ordering Information*	11
7	1/20	Updated *Ordering Information*	1
8	8/21	Updated *Ordering Information*	1, 11