



Precision, Micropower, 1.8V Supply, Low-Dropout, SOT23 Voltage Reference

MAX6018

General Description

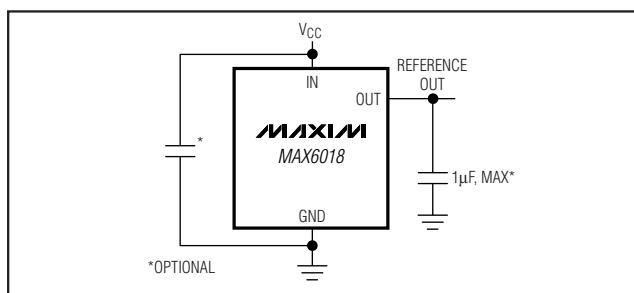
The MAX6018 is a precision, low-voltage, low-dropout, micropower voltage reference in a SOT23 package. This three-terminal reference operates with an input voltage from ($V_{OUT} + 200\text{mV}$) to 5.5V, and is available with output voltage options of 1.2V, 1.6V, 1.8V, and 2.048V

The MAX6018 voltage reference consumes less than 5 μA (max) of supply current and can source and sink up to 1mA of load current. Unlike conventional shunt-mode (two-terminal) references that waste supply current and require an external resistor, devices in the MAX6018 family offer a supply current that is virtually independent of supply voltage (with only 0.1 $\mu\text{A/V}$ variation with supply voltage) and do not require an external resistor. The MAX6018 has initial accuracies of 0.2% (A grade) and 0.4% (B grade) and temperature drift of 50ppm/ $^{\circ}\text{C}$ (max). The low-dropout voltage and the ultra-low, supply voltage-independent supply current make this device ideal for two-cell alkaline, end-of-life, battery-monitoring systems. The MAX6018 is available in a tiny 3-pin SOT23 package.

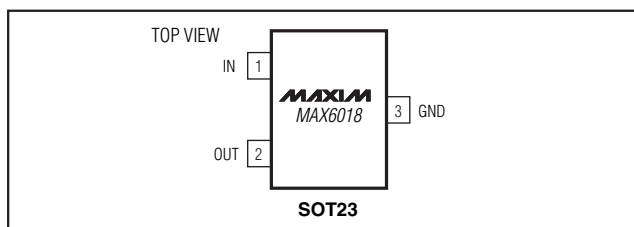
Applications

Two-Cell, Battery-Operated Systems
Battery-Operated Equipment
Hand-Held Equipment
Data-Acquisition Systems
Industrial and Process-Control Systems

Typical Application Circuit



Pin Configuration



Features

- ◆ Ultra-Low Supply Current: 5 μA (max)
- ◆ 1.6V Output from 1.8V Input
- ◆ Ultra-Small, 3-Pin SOT23 Package
- ◆ Initial Accuracy: $\pm 0.2\%$ (max)
- ◆ Low Temperature Drift: 50ppm/ $^{\circ}\text{C}$ (max)
- ◆ 200mV Dropout Voltage
- ◆ Load Regulation (1mA Source): 700 $\mu\text{V}/\text{mA}$ (max)
- ◆ Line Regulation ($V_{OUT} + 200\text{mV}$) to 5.5V: 250 $\mu\text{V}/\text{V}$ (max)
- ◆ Four Output Voltage Options: 1.2V, 1.6V, 1.8V, 2.048V

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX6018AEUR12-T	-40 $^{\circ}\text{C}$ to +85 $^{\circ}\text{C}$	3 SOT23-3	FZJH
MAX6018BEUR12-T	-40 $^{\circ}\text{C}$ to +85 $^{\circ}\text{C}$	3 SOT23-3	FZJI
MAX6018AEUR16-T	-40 $^{\circ}\text{C}$ to +85 $^{\circ}\text{C}$	3 SOT23-3	FZJJ
MAX6018BEUR16-T	-40 $^{\circ}\text{C}$ to +85 $^{\circ}\text{C}$	3 SOT23-3	FZJK
MAX6018AEUR18-T	-40 $^{\circ}\text{C}$ to +85 $^{\circ}\text{C}$	3 SOT23-3	FZJL
MAX6018BEUR18-T	-40 $^{\circ}\text{C}$ to +85 $^{\circ}\text{C}$	3 SOT23-3	FZJM
MAX6018AEUR21-T	-40 $^{\circ}\text{C}$ to +85 $^{\circ}\text{C}$	3 SOT23-3	FZJN
MAX6018BEUR21-T	-40 $^{\circ}\text{C}$ to +85 $^{\circ}\text{C}$	3 SOT23-3	FZJO

Selector Guide

PART	OUTPUT VOLTAGE (V)	INITIAL ACCURACY (%)
MAX6018AEUR12	1.263	± 0.2
MAX6018BEUR12	1.263	± 0.4
MAX6018AEUR16	1.600	± 0.2
MAX6018BEUR16	1.600	± 0.4
MAX6018AEUR18	1.800	± 0.2
MAX6018BEUR18	1.800	± 0.4
MAX6018AEUR21	2.048	± 0.2
MAX6018BEUR21	2.048	± 0.4



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ABSOLUTE MAXIMUM RATINGS

(Voltages Referenced to GND)

V_{IN} -0.3V to +6V

Output Short-Circuit Duration to GND or V_{IN} Continuous

Continuous Power Dissipation ($T_A = +70^\circ\text{C}$)

3-Pin SOT23 (derate 4.0mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$) 320mW

Operating Temperature Range -40°C to $+85^\circ\text{C}$

Junction Temperature $+150^\circ\text{C}$

Storage Temperature Range -65°C to $+150^\circ\text{C}$

Lead Temperature (soldering, 10s) $+300^\circ\text{C}$

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 (MAX6018_12–1.263V)

($V_{IN} = 1.8\text{V}$; $C_{OUT} = 47\text{nF}$, $I_{OUT} = 0$; $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ\text{C}$.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
OUTPUT						
Output Voltage	V_{OUT}	MAX6018A_12 (0.2%)	1.2605	1.2630	1.2655	V
		MAX6018B_12 (0.4%)	1.2580	1.2630	1.2681	
Output Voltage Temperature Drift	TCV_{OUT}	(Note 2)		16	50	ppm/ $^\circ\text{C}$
Line Regulation	$\Delta V_{OUT}/\Delta V_{IN}$	$1.8\text{V} \leq V_{IN} \leq 5.5\text{V}$		50	400	$\mu\text{V}/\text{V}$
Load Regulation	$\Delta V_{OUT}/\Delta I_{OUT}$	$0 \leq I_{OUT} \leq 1\text{mA}$		90	700	$\mu\text{V}/\text{mA}$
		$-100\mu\text{A} \leq I_{OUT} \leq 0$		2	9	$\mu\text{V}/\mu\text{A}$
Short-Circuit Current	I_{SC}	Sourcing to GND		3		mA
		Sinking from V_{IN}		6		
Long-Term Stability	$\Delta V_{OUT}/\text{Time}$	1000hrs at $T_A = +25^\circ\text{C}$		100		ppm
Thermal Hysteresis		(Note 4)		130		ppm
DYNAMIC CHARACTERISTICS						
Noise Voltage	e_{OUT}	0.1Hz to 10Hz		45		$\mu\text{Vp-p}$
		10Hz to 10kHz		100		μVRMS
Ripple Rejection		$V_{IN} = 1.8\text{V} \pm 100\text{mV}$ ($f = 120\text{Hz}$)		85		dB
Turn-On Settling Time	t_R	Settling to 0.1%; $C_{OUT} = 5\text{nF}$		200		μs
Capacitive-Load Stability Range	C_{OUT}	(Note 2)	47		1000	nF
INPUT						
Supply Voltage Range	V_{IN}	Guaranteed by Line Regulation Test	1.8		5.5	V
Quiescent Supply Current	I_{IN}	$T_A = +25^\circ\text{C}$		3	5	μA
		$T_A = T_{MIN}$ to T_{MAX}		3	6	
Change in Quiescent Supply Current vs. Input Voltage	$\Delta I_{IN}/\Delta V_{IN}$	$1.8\text{V} \leq V_{IN} \leq 5.5\text{V}$		0.1	0.5	$\mu\text{A}/\text{V}$

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ELECTRICAL CHARACTERISTICS (MAX6018_16–1.600V)

($V_{IN} = 1.8V$; $C_{OUT} = 47nF$, $I_{OUT} = 0$; $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
OUTPUT							
Output Voltage	V _{OUT}	MAX6018A_16 (0.2%)	T _A = +25°C	1.5968	1.6000	1.6032	V
		MAX6018B_16 (0.4%)	T _A = +25°C	1.5936	1.6000	1.6064	
Output Voltage Temperature Drift	TCV _{OUT}	(Note 2)		16		50	ppm/°C
Line Regulation	ΔV _{OUT} /ΔV _{IN}	1.8V ≤ V _{IN} ≤ 5.5V		40		250	μV/V
Load Regulation	ΔV _{OUT} /ΔI _{OUT}	0 ≤ I _{OUT} ≤ 1mA		90		700	μV/mA
		-750μA ≤ I _{OUT} ≤ 0		0.6		50	μV/μA
Dropout Voltage (Note 3)	V _{IN} - V _{OUT}	I _{OUT} = 1mA		100		200	mV
Short-Circuit Current	I _{SC}	Sourcing to GND		6			mA
		Sinking from V _{IN}		2			
Long-Term Stability	ΔV _{OUT} /Time	1000hrs at T _A = +25°C		100			ppm
Thermal Hysteresis		(Note 4)		130			ppm
DYNAMIC CHARACTERISTICS							
Noise Voltage	e _{OUT}	0.1Hz to 10Hz		40			μVp-p
		10Hz to 10kHz		150			μVRMS
Ripple Rejection		V _{IN} = 1.8V ±100mV (f = 120Hz)		85			dB
Turn-On Settling Time	t _R	Settling to 0.1%; C _{OUT} = 5nF		200			μs
Capacitive-Load Stability Range	C _{OUT}	(Note 2)		0.1		1000	nF
INPUT							
Supply Voltage Range	V _{IN}	Guaranteed by Line Regulation Test		1.8		5.5	V
Quiescent Supply Current	I _{IN}	T _A = +25°C		3		5	μA
		T _A = T _{MIN} to T _{MAX}		3		6	
Change in Quiescent Supply Current vs. Input Voltage	ΔI _{IN} /ΔV _{IN}	1.8V ≤ V _{IN} ≤ 5.5V		0.1		0.5	μA/V

Precision, Micropower, 1.8V Supply, Low-Dropout, SOT23 Voltage Reference

ELECTRICAL CHARACTERISTICS (MAX6018_18–1.800V)

($V_{IN} = 2.0V$; $C_{OUT} = 47nF$, $I_{OUT} = 0$; $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
OUTPUT							
Output Voltage	V _{OUT}	MAX6018A_18 (0.2%)	T _A = +25°C	1.7964	1.8000	1.8036	V
		MAX6018B_18 (0.4%)	T _A = +25°C	1.7928	1.8000	1.8072	
Output Voltage Temperature Drift	TCV _{OUT}	(Note 2)		16		50	ppm/°C
Line Regulation	ΔV _{OUT} /ΔV _{IN}	2.0V ≤ V _{IN} ≤ 5.5V		40		275	μV/V
Load Regulation	ΔV _{OUT} /ΔI _{OUT}	0 ≤ I _{OUT} ≤ 1mA		90		800	μV/mA
		-1mA ≤ I _{OUT} ≤ 0		0.4		50	μV/μA
Dropout Voltage (Note 3)	V _{IN} - V _{OUT}	I _{OUT} = 1mA		100		200	mV
Short-Circuit Current	I _{SC}	Sourcing to GND		7.5			mA
		Sinking from V _{IN}		3			
Long-Term Stability	ΔV _{OUT} /Time	1000hrs at T _A = +25°C		100			ppm
Thermal Hysteresis		(Note 4)		130			ppm
DYNAMIC CHARACTERISTICS							
Noise Voltage	e _{OUT}	0.1Hz to 10Hz		45			μVp-p
		10Hz to 10kHz		160			μVRMS
Ripple Rejection		V _{IN} = 2.0V ±100mV (f = 120Hz)		85			dB
Turn-On Settling Time	t _R	Settling to 0.1%; C _{OUT} = 5nF		200			μs
Capacitive-Load Stability Range	C _{OUT}	(Note 2)		0.1		1000	nF
INPUT							
Supply Voltage Range	V _{IN}	Guaranteed by Line Regulation Test		2.0		5.5	V
Quiescent Supply Current	I _{IN}	T _A = +25°C		3		5	μA
		T _A = T _{MIN} to T _{MAX}		3		6	
Change in Quiescent Supply Current vs. Input Voltage	ΔI _{IN} /ΔV _{IN}	2V ≤ V _{IN} ≤ 5.5V		0.1		0.5	μA/V

Precision, Micropower, 1.8V Supply, Low-Dropout, SOT23 Voltage Reference

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ELECTRICAL CHARACTERISTICS (MAX6018_21–2.048V)

($V_{IN} = 2.25V$; $C_{OUT} = 47nF$, $I_{OUT} = 0$; $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^{\circ}C$.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
OUTPUT							
Output Voltage	V _{OUT}	MAX6018A_21 (0.2%)	T _A = +25°C	2.0439	2.0480	2.0521	V
		MAX6018B_21 (0.4%)	T _A = +25°C	2.0398	2.0480	2.0562	
Output Voltage Temperature Drift	TCV _{OUT}	(Note 2)		16		50	ppm/°C
Line Regulation	ΔV _{OUT} /ΔV _{IN}	2.25V ≤ V _{IN} ≤ 5.5V		45		330	μV/V
Load Regulation	ΔV _{OUT} /ΔI _{OUT}	0 ≤ I _{OUT} ≤ 1mA		90		1000	μV/mA
		-1mA ≤ I _{OUT} ≤ 0		0.3		50	μV/μA
Dropout Voltage (Note 3)	V _{IN} - V _{OUT}	I _{OUT} = 1mA		100		200	mV
Short-Circuit Current	I _{SC}	Sourcing to GND		10			mA
		Sinking from V _{IN}		4			
Long-Term Stability	ΔV _{OUT} /Time	1000hrs at T _A = +25°C		100			ppm
Thermal Hysteresis		(Note 4)		130			ppm
DYNAMIC CHARACTERISTICS							
Noise Voltage	e _{OUT}	0.1Hz to 10Hz		50			μVp-p
		10Hz to 10kHz		175			μVRMS
Ripple Rejection		V _{IN} = 2.25V ±100mV (f = 120Hz)		85			dB
Turn-On Settling Time	t _R	Settling to 0.1%; C _{OUT} = 5nF		200			μs
Capacitive-Load Stability Range	C _{OUT}	(Note 2)		0.1		1000	nF
INPUT							
Supply Voltage Range	V _{IN}	Guaranteed by Line Regulation Test		2.25		5.5	V
Quiescent Supply Current	I _{IN}	T _A = +25°C		3		5	μA
		T _A = T _{MIN} to T _{MAX}		3		6	
Change in Quiescent Supply Current vs. Input Voltage	ΔI _{IN} /ΔV _{IN}	2.25V ≤ V _{IN} ≤ 5.5V		0.1		0.5	μA/V

Note 1: Devices are 100% production tested at $T_A = +25^{\circ}C$ and are guaranteed by design from $T_A = T_{MIN}$ to T_{MAX} .

Note 2: Not production tested. Guaranteed by design.

Note 3: Dropout voltage is the minimum input voltage at which V_{OUT} changes $\leq 0.2\%$ from V_{OUT} at rated V_{IN} and is guaranteed by Load Regulation Test.

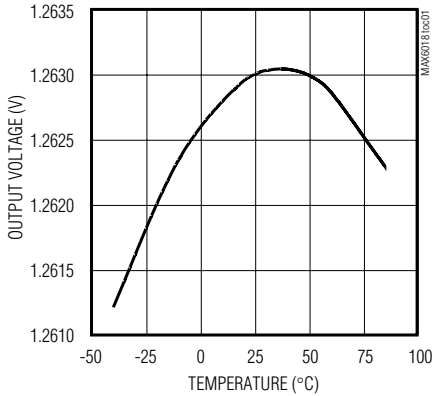
Note 4: Thermal hysteresis is defined as the change in $T_A = +25^{\circ}C$ output voltage before and after temperature cycling of the device (from $T_A = T_{MIN}$ to T_{MAX}). Initial measurement at $T_A = +25^{\circ}C$ is followed by temperature cycling the device to $T_A = +85^{\circ}C$ then to $T_A = -40^{\circ}C$ and another measurement at $T_A = +25^{\circ}C$ is compared to the original measurement at $T_A = +25^{\circ}C$.

Precision, Micropower, 1.8V Supply, Low-Dropout, SOT23 Voltage Reference

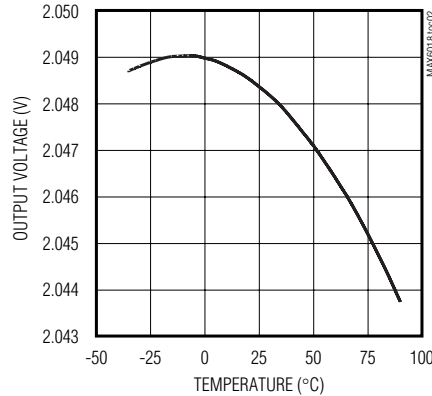
Typical Operating Characteristics

($T_A = +25^\circ\text{C}$, unless otherwise noted.)

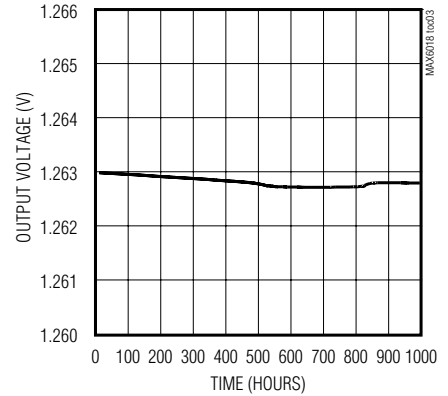
MAX6018_12
OUTPUT VOLTAGE DRIFT vs. TEMPERATURE



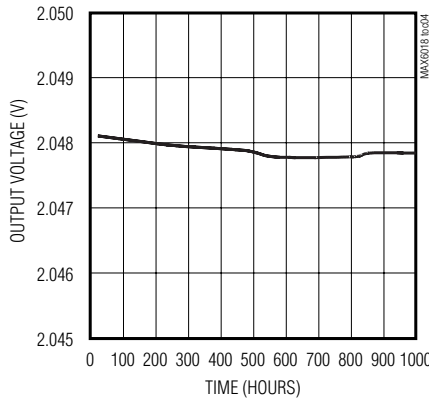
MAX6018_21
OUTPUT VOLTAGE DRIFT vs. TEMPERATURE



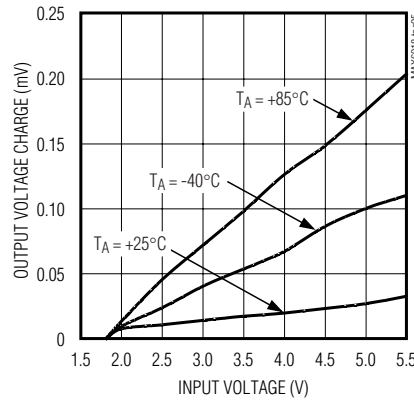
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LONG-TERM DRIFT



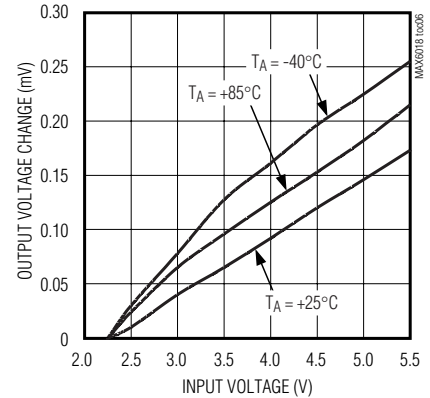
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LONG-TERM DRIFT



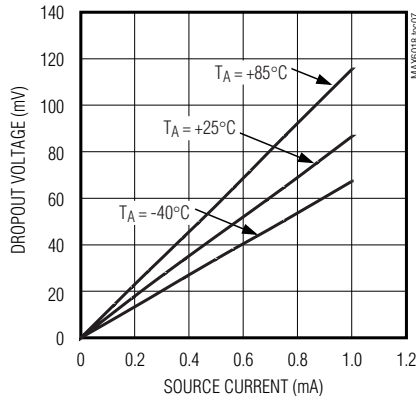
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LINE REGULATION



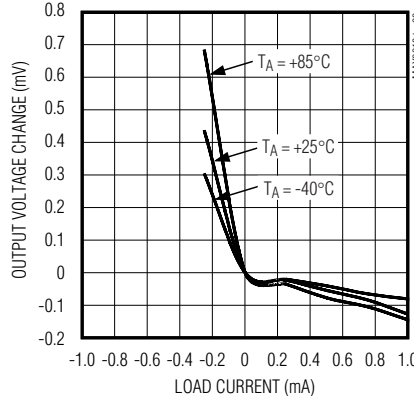
MAX6018_21
LINE REGULATION



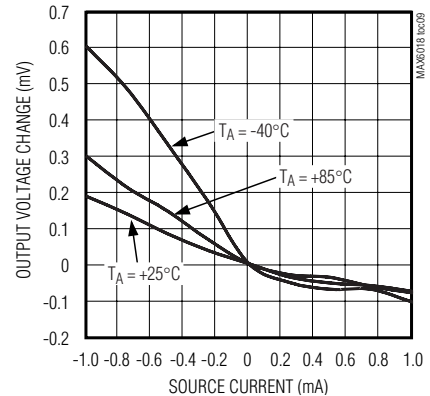
MAX6018_21
DROPOUT VOLTAGE vs. SOURCE CURRENT



MAX6018_12
LOAD REGULATION



MAX6018_21
LOAD REGULATION



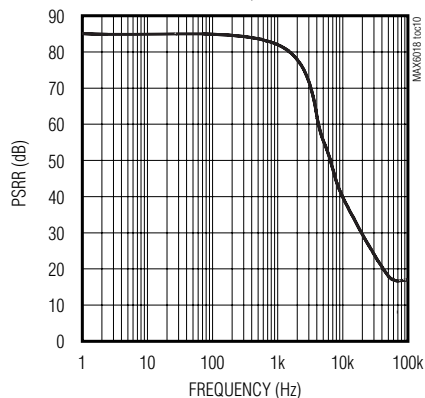
Precision, Micropower, 1.8V Supply, Low-Dropout, SOT23 Voltage Reference

Typical Operating Characteristics (continued)

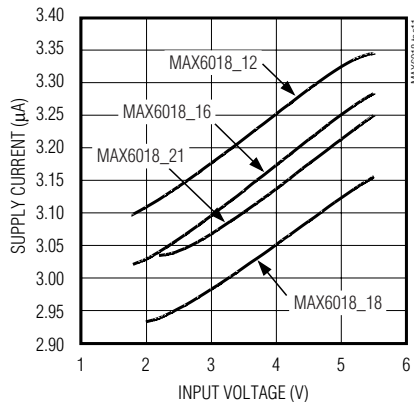
($T_A = +25^\circ\text{C}$, unless otherwise noted.)

MAX6018

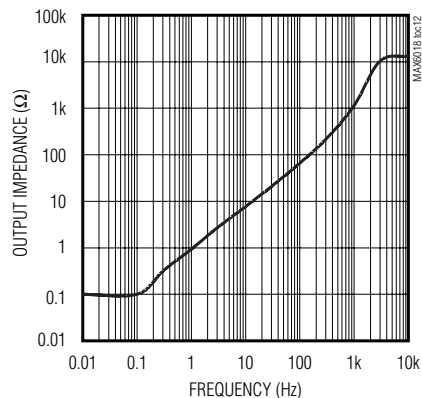
POWER-SUPPLY REJECTION RATIO vs. FREQUENCY



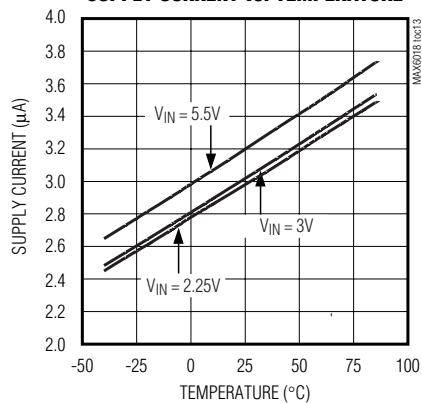
SUPPLY CURRENT vs. INPUT VOLTAGE



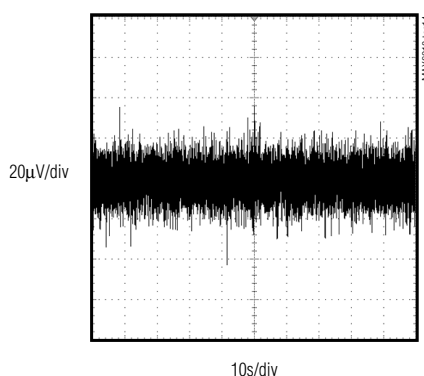
OUTPUT IMPEDANCE vs. FREQUENCY



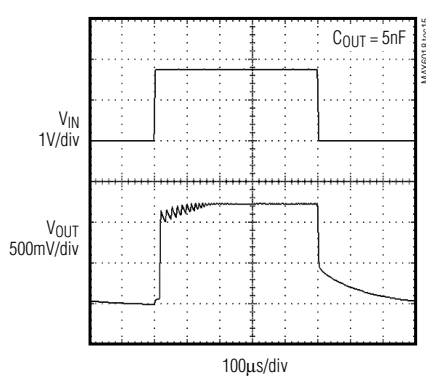
SUPPLY CURRENT vs. TEMPERATURE



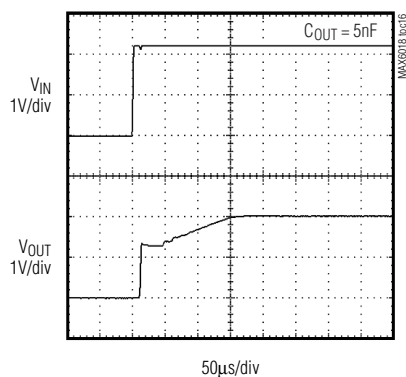
**MAX6018_21
0.1Hz TO 10Hz OUTPUT NOISE**



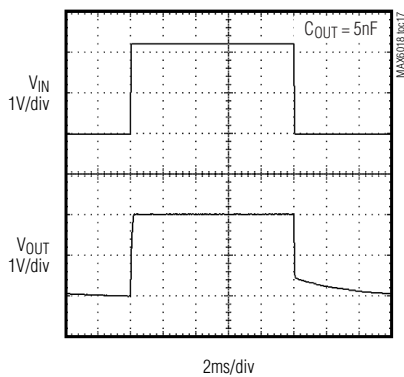
**MAX6018_12
TURN-ON TRANSIENT**



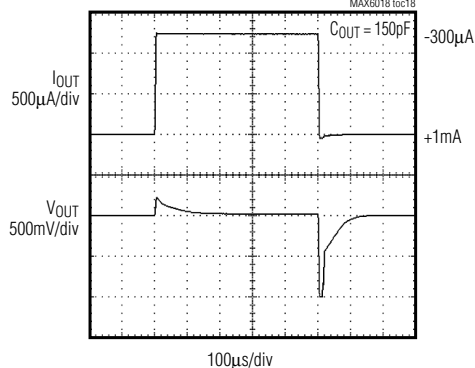
**MAX6018_21
TURN-ON TRANSIENT**



**MAX6018_21
TURN-OFF TRANSIENT**



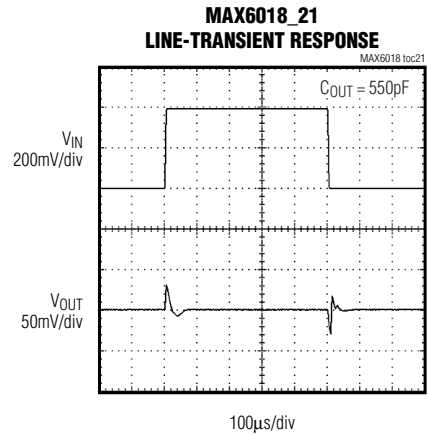
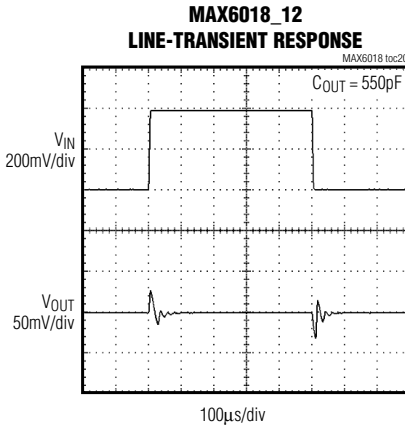
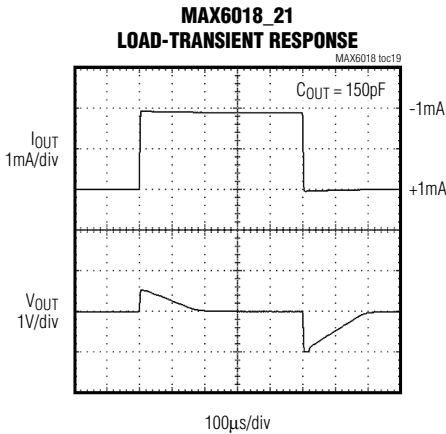
**MAX6018_12
LOAD-TRANSIENT RESPONSE**



Precision, Micropower, 1.8V Supply, Low-Dropout, SOT23 Voltage Reference

Typical Operating Characteristics (continued)

($T_A = +25^\circ\text{C}$, unless otherwise noted.)



Detailed Description

The MAX6018 is a precision, low-voltage, low-dropout, micropower, bandgap voltage reference in a SOT23 package. This three-terminal reference operates with an input voltage from ($V_{OUT} + 200\text{mV}$) to 5.5V, and is available with output voltage options of 1.2V, 1.6V, 1.8V, and 2.048V. These devices can source up to 1mA with $<200\text{mV}$ of dropout voltage, making them attractive for use in low-voltage applications.

Applications Information

Output/Load Capacitance

These devices require a minimum of 100pF load to maintain output stability.

They remain stable for capacitive loads as high as 1µF. In applications where the load or the supply can experience step changes, a larger output capacitor reduces the amount of overshoot (or undershoot) and assists the circuit's transient response. Otherwise, applications may not need more than 100pF.

Supply Current

The 5µA maximum supply current varies only 0.1µA/V with the supply voltage.

When the supply voltage is below the minimum-specified input voltage (as during turn-on), the devices can draw up to 20µA beyond the nominal supply current. The input voltage source must be capable of providing this current to ensure reliable turn-on.

Pin Description

PIN	NAME	FUNCTION
1	IN	Supply Voltage Input. Bypass with a 0.1µF capacitor to ground.
2	OUT	Reference Voltage Output. Bypass with at least 100pF to ground. (See <i>Output/Load Capacitance</i> section).
3	GND	Ground

Turn-On Time

These devices typically turn on and settle to within 0.1% of their final value in 200µs. The turn-on time can increase up to 1ms with the device operating at the minimum dropout voltage and the maximum load.

Chip Information

TRANSISTOR COUNT: 87

PROCESS: BiCMOS

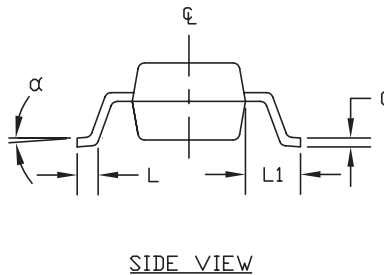
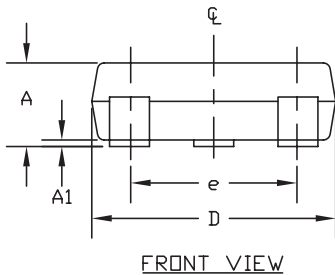
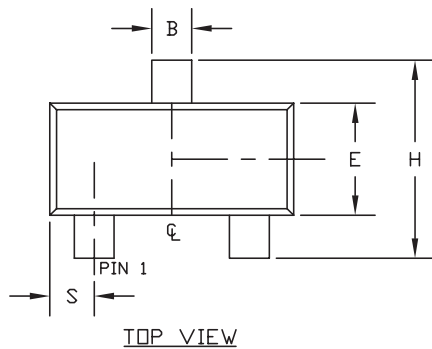
Precision, Micropower, 1.8V Supply, Low-Dropout, SOT23 Voltage Reference

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-integrated.com/packages.)

NOTES:

1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006").
3. CONTROLLING DIMENSION: MILLIMETERS.
4. REFERENCE JEDEC TO236.
5. LEADS TO BE COPLANAR WITHIN 0.10mm.



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.035	0.044	0.890	1.120
A1	0.001	0.004	0.013	0.100
B	0.015	0.020	0.370	0.510
C	0.003	0.071	0.085	0.180
D	0.110	0.120	2.800	3.040
E	0.047	0.055	1.200	1.400
e	0.070	0.081	1.780	2.050
H	0.083	0.104	2.100	2.640
L	0.008	0.017	0.210	0.420
L1	0.021	REF	0.54	REF
S	0.018	0.024	0.45	0.60
α	0°	8°	0°	8°

PROPRIETARY INFORMATION			
TITLE: PACKAGE OUTLINE, 3L SOT-23			
APPROVAL	DOCUMENT CONTROL NO. 21-0051	REV. E	1/1

SOT23 LEPS

MAX6018

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