19-4777; Rev 3; 4/01

MAXIM

# Precision, Low-Power, Low-Dropout, SOT23-3 Voltage References



## General Description

The MAX6012/MAX6021/MAX6025/MAX6030/MAX6041/MAX6045/MAX6050 precision, low-dropout, micropower voltage references are available in miniature SOT23-3 surface-mount packages. They feature a proprietary curvature-correction circuit and laser-trimmed thin-film resistors that result in a low temperature coefficient of <15ppm/°C and initial accuracy of better than 0.2%. These devices are specified over the extended temperature range.

These series-mode voltage references draw only 27µA of quiescent supply current and can sink or source up to 500µA of load current. Unlike conventional shunt-mode (two-terminal) references that waste supply current and require an external resistor, devices in the MAX6012 family offer a supply current that's virtually independent of supply voltage (with only a 0.8µA/V variation with supply voltage) and do not require an external resistor. Additionally, these internally compensated devices do not require an external compensation capacitor and are stable with up to 2.2nF of load capacitance. Eliminating the external compensation capacitor saves valuable board area in space-critical applications. Their low dropout voltage and supply-independent, ultra-low supply current make these devices ideal for battery-operated, low-voltage systems.

## Applications

Hand-Held Equipment

Data Acquisition Systems

Industrial and Process-Control Systems

Battery-Operated Equipment

Hard-Disk Drives

## Selector Guide

| PART | OUTPUT VOLTAGE (V) | INPUT VOLTAGE (V) |
|---|---|---|
| MAX6012 | 1.247 | 2.5 to 12.6 |
| MAX6021 | 2.048 | 2.5 to 12.6 |
| MAX6025 | 2.500 | ($V_{OUT}$ + 200mV) to 12.6 |
| MAX6030 | 3.000 | ($V_{OUT}$ + 200mV) to 12.6 |
| MAX6041 | 4.096 | ($V_{OUT}$ + 200mV) to 12.6 |
| MAX6045 | 4.500 | ($V_{OUT}$ + 200mV) to 12.6 |
| MAX6050 | 5.000 | ($V_{OUT}$ + 200mV) to 12.6 |

***Pin Configuration appears at end of data sheet.***

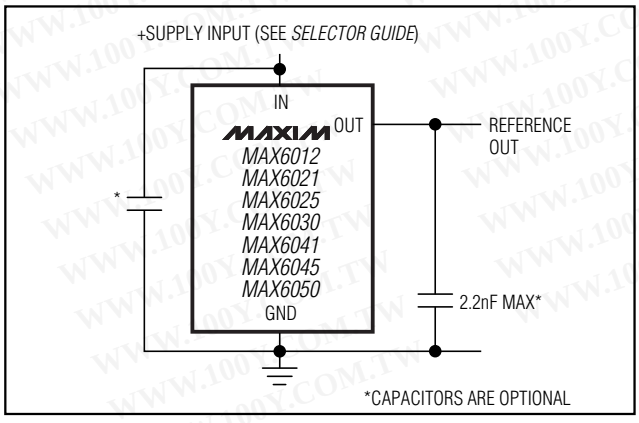
## Features

- **0.2% (max) Initial Accuracy**
- **15ppm/°C (max) Temperature Coefficient**
- **35µA (max) Quiescent Supply Current**
- **0.8µA/V Supply Current Variation with $V_{IN}$**
- **±500µA Output Source and Sink Current**
- **100mV Dropout at 500µA Load Current**
- **0.12µV/µA Load Regulation**
- **8µV/V Line Regulation**
- **Stable with $C_{LOAD}$ = 0 to 2.2nF**

## Ordering Information

| PART | TEMP. RANGE | PIN-PACKAGE | TOP MARK |
|---|---|---|---|
| **MAX6012**AEUR-T | -40°C to +85°C | 3 SOT23-3 | FZAP |
| MAX6012BEUR-T | -40°C to +85°C | 3 SOT23-3 | FZDA |
| **MAX6021**AEUR-T | -40°C to +85°C | 3 SOT23-3 | FZAU |
| MAX6021BEUR-T | -40°C to +85°C | 3 SOT23-3 | FZDF |
| **MAX6025**AEUR-T | -40°C to +85°C | 3 SOT23-3 | FZAQ |
| MAX6025BEUR-T | -40°C to +85°C | 3 SOT23-3 | FZDB |
| **MAX6030**AEUR-T | -40°C to +85°C | 3 SOT23-3 | FZDW |
| MAX6030BEUR-T | -40°C to +85°C | 3 SOT23-3 | FZDX |
| **MAX6041**AEUR-T | -40°C to +85°C | 3 SOT23-3 | FZAR |
| MAX6041BEUR-T | -40°C to +85°C | 3 SOT23-3 | FZDC |
| **MAX6045**AEUR-T | -40°C to +85°C | 3 SOT23-3 | FZAS |
| MAX6045BEUR-T | -40°C to +85°C | 3 SOT23-3 | FZDD |
| **MAX6050**AEUR-T | -40°C to +85°C | 3 SOT23-3 | FZAT |
| MAX6050BEUR-T | -40°C to +85°C | 3 SOT23-3 | FZDE |

## Typical Operating Circuit



# Precision, Low-Power, Low-Dropout, SOT23-3 Voltage References

## ABSOLUTE MAXIMUM RATINGS

(Voltages Referenced to GND)
IN .....-0.3V to +13.5V
OUT .....-0.3V to ($V_{IN}$ + 0.3V)
Output Short Circuit to GND or IN ($V_{IN}$ < 6V) .....Continuous
Output Short Circuit to GND or IN ($V_{IN}$ ≥ 6V) .....60s

Continuous Power Dissipation ($T_A$ = +70°C)
3-Pin SOT23-3 (derate 4.0mW/°C above +70°C) .....320mW
Operating Temperature Range .....-40°C to +85°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—MAX6012

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

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **OUTPUT** | | | | | | | |
| Output Voltage | $V_{OUT}$ | $T_A$ = +25°C | MAX6012A | 1.243 | 1.247 | 1.251 | V |
| | | | | -0.32 | | 0.32 | % |
| | | | MAX6012B | 1.241 | 1.247 | 1.253 | V |
| | | | | -0.48 | | 0.48 | % |
| Output Voltage Temperature Coefficient (Note 2) | $V_{OUT}$ | $T_A$ = 0°C to +70°C | MAX6012A | | 6 | 15 | ppm/°C |
| | | $T_A$ = -40°C to +85°C | | | 6 | 20 | |
| | | $T_A$ = 0°C to +70°C | MAX6012B | | 6 | 25 | |
| | | $T_A$ = -40°C to +85°C | | | 6 | 30 | |
| Line Regulation | $\Delta V_{OUT}/\Delta V_{IN}$ | 2.5V ≤ $V_{IN}$ ≤ 12.6V | | | 8 | 80 | µV/V |
| Load Regulation | $\Delta V_{OUT}/\Delta I_{OUT}$ | Sourcing: 0 ≤ $I_{OUT}$ ≤ 500µA | | | 0.12 | 0.50 | µV/µA |
| | | Sinking: -500µA ≤ $I_{OUT}$ ≤ 0 | | | 0.15 | 0.60 | |
| OUT Short-Circuit Current | $I_{SC}$ | Short to GND | | | 4 | | mA |
| | | Short to IN | | | 4 | | |
| Temperature Hysteresis (Note 3) | | | | | 130 | | ppm |
| Long-Term Stability | $\Delta V_{OUT}$/time | 1000hr at $T_A$ = +25°C | | | 50 | | ppm/1000hr |
| **DYNAMIC** | | | | | | | |
| Noise Voltage | $e_{OUT}$ | f = 0.1Hz to 10Hz | | | 12 | | µVp-p |
| | | f = 10Hz to 10kHz | | | 65 | | $\mu V_{RMS}$ |
| Ripple Rejection | $\Delta V_{OUT}/\Delta V_{IN}$ | $V_{IN}$ = 5V ±100mV, f = 120Hz | | | 86 | | dB |
| Turn-On Settling Time | $t_R$ | To $V_{OUT}$ = 0.1% of final value, $C_{OUT}$ = 50pF | | | 30 | | µs |
| Capacitive-Load Stability Range | $C_{OUT}$ | Note 4 | | 0 | | 2.2 | nF |
| **INPUT** | | | | | | | |
| Supply Voltage Range | $V_{IN}$ | Guaranteed by line-regulation test | | 2.5 | | 12.6 | V |
| Quiescent Supply Current | $I_{IN}$ | | | | 27 | 35 | µA |
| Change in Supply Current | $I_{IN}/V_{IN}$ | 2.5V ≤ $V_{IN}$ ≤ 12.6V | | | 0.8 | 2.0 | µA/V |

## ELECTRICAL CHARACTERISTICS—MAX6021

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

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **OUTPUT** | | | | | | | |
| Output Voltage | $V_{OUT}$ | $T_A$ = +25°C | MAX6021A | 2.043 | 2.048 | 2.053 | V |
| | | | | -0.24 | | 0.24 | % |
| | | | MAX6021B | 2.040 | 2.048 | 2.056 | V |
| | | | | -0.39 | | 0.39 | % |
| Output Voltage Temperature Coefficient (Note 2) | $V_{OUT}$ | $T_A$ = 0°C to +70°C | MAX6021A | | 6 | 15 | ppm/°C |
| | | $T_A$ = -40°C to +85°C | | | 6 | 20 | |
| | | $T_A$ = 0°C to +70°C | MAX6021B | | 6 | 25 | |
| | | $T_A$ = -40°C to +85°C | | | 6 | 30 | |
| Line Regulation | $\Delta V_{OUT}/\Delta V_{IN}$ | 2.5V ≤ $V_{IN}$ ≤ 12.6V | | | 10 | 100 | µV/V |
| Load Regulation | $\Delta V_{OUT}/\Delta I_{OUT}$ | Sourcing: 0 ≤ $I_{OUT}$ ≤ 500µA | | | 0.12 | 0.55 | µV/µA |
| | | Sinking: -500µA ≤ $I_{OUT}$ ≤ 0 | | | 0.18 | 0.70 | |
| OUT Short-Circuit Current | $I_{SC}$ | Short to GND | | | 4 | | mA |
| | | Short to IN | | | 4 | | |
| Temperature Hysteresis (Note 3) | | | | | 130 | | ppm |
| Long-Term Stability | $\Delta V_{OUT}$/time | 1000hr at $T_A$ = +25°C | | | 50 | | ppm/1000hr |
| **DYNAMIC** | | | | | | | |
| Noise Voltage | $e_{OUT}$ | f = 0.1Hz to 10Hz | | | 35 | | µVp-p |
| | | f = 10Hz to 10kHz | | | 105 | | $\mu V_{RMS}$ |
| Ripple Rejection | $\Delta V_{OUT}/\Delta V_{IN}$ | $V_{IN}$ = 5V ±100mV, f = 120Hz | | | 84 | | dB |
| Turn-On Settling Time | $t_R$ | To $V_{OUT}$ = 0.1% of final value, $C_{OUT}$ = 50pF | | | 70 | | µs |
| Capacitive-Load Stability Range | $C_{OUT}$ | Note 4 | | 0 | | 2.2 | nF |
| **INPUT** | | | | | | | |
| Supply Voltage Range | $V_{IN}$ | Guaranteed by line-regulation test | | 2.5 | | 12.6 | V |
| Quiescent Supply Current | $I_{IN}$ | | | | 27 | 35 | µA |
| Change in Supply Current | $I_{IN}/V_{IN}$ | 2.5V ≤ $V_{IN}$ ≤ 12.6V | | | 0.8 | 2.0 | µA/V |

# Precision, Low-Power, Low-Dropout, SOT23-3 Voltage References

## ELECTRICAL CHARACTERISTICS—MAX6025

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

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **OUTPUT** | | | | | | | |
| Output Voltage | $V_{OUT}$ | $T_A$ = +25°C | MAX6025A | 2.495 | 2.500 | 2.505 | V |
| | | | | -0.20 | | 0.20 | % |
| | | | MAX6025B | 2.490 | 2.500 | 2.510 | V |
| | | | | -0.40 | | 0.40 | % |
| Output Voltage Temperature Coefficient (Note 2) | $V_{OUT}$ | $T_A$ = 0°C to +70°C | MAX6025A | | 6 | 15 | ppm/°C |
| | | $T_A$ = -40°C to +85°C | | | 6 | 20 | |
| | | $T_A$ = 0°C to +70°C | MAX6025B | | 6 | 25 | |
| | | $T_A$ = -40°C to +85°C | | | 6 | 30 | |
| Line Regulation | $\Delta V_{OUT}/\Delta V_{IN}$ | ($V_{OUT}$ + 0.2V) ≤ $V_{IN}$ ≤ 12.6V | | | 15 | 140 | µV/V |
| Load Regulation | $\Delta V_{OUT}/\Delta I_{OUT}$ | Sourcing: 0 ≤ $I_{OUT}$ ≤ 500µA | | | 0.14 | 0.60 | µV/µA |
| | | Sinking: -500µA ≤ $I_{OUT}$ ≤ 0 | | | 0.18 | 0.80 | |
| Dropout Voltage (Note 5) | $V_{IN}$ - $V_{OUT}$ | $I_{OUT}$ = 500µA | | | 100 | 200 | mV |
| OUT Short-Circuit Current | $I_{SC}$ | Short to GND | | | 4 | | mA |
| | | Short to IN | | | 4 | | |
| Temperature Hysteresis (Note 3) | $\Delta V_{OUT}$/time | | | | 130 | | ppm |
| Long-Term Stability | $\Delta V_{OUT}$/time | 1000hr at $T_A$ = +25°C | | | 50 | | ppm/1000hr |
| **DYNAMIC** | | | | | | | |
| Noise Voltage | $e_{OUT}$ | f = 0.1Hz to 10Hz | | | 50 | | µVp-p |
| | | f = 10Hz to 10kHz | | | 125 | | $\mu V_{RMS}$ |
| Ripple Rejection | $\Delta V_{OUT}/\Delta V_{IN}$ | $V_{IN}$ = 5V ±100mV, f = 120Hz | | | 82 | | dB |
| Turn-On Settling Time | $t_R$ | To $V_{OUT}$ = 0.1% of final value, $C_{OUT}$ = 50pF | | | 85 | | µs |
| Capacitive-Load Stability Range | $C_{OUT}$ | Note 4 | | 0 | | 2.2 | nF |
| **INPUT** | | | | | | | |
| Supply Voltage Range | $V_{IN}$ | Guaranteed by line-regulation test | | $V_{OUT}$ + 0.2 | | 12.6 | V |
| Quiescent Supply Current | $I_{IN}$ | | | | 27 | 35 | µA |
| Change in Supply Current | $I_{IN}/V_{IN}$ | ($V_{OUT}$ + 0.2V) ≤ $V_{IN}$ ≤ 12.6V | | | 0.8 | 2.0 | µA/V |

## ELECTRICAL CHARACTERISTICS—MAX6030

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

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **OUTPUT** | | | | | | | |
| Output Voltage | $V_{OUT}$ | $T_A$ = +25°C | MAX6030A | 2.994 | 3.000 | 3.006 | V |
| | | | | -0.20 | | 0.20 | % |
| | | | MAX6030B | 2.988 | 3.000 | 3.012 | V |
| | | | | -0.40 | | 0.40 | % |
| Output Voltage Temperature Coefficient (Note 2) | $V_{OUT}$ | $T_A$ = 0°C to +70°C | MAX6030A | | 6 | 15 | ppm/°C |
| | | $T_A$ = -40°C to +85°C | | | 6 | 20 | |
| | | $T_A$ = 0°C to +70°C | MAX6030B | | 6 | 25 | |
| | | $T_A$ = -40°C to +85°C | | | 6 | 30 | |
| Line Regulation | $\Delta V_{OUT}/\Delta V_{IN}$ | ($V_{OUT}$) +0.2V) ≤ $V_{IN}$ ≤ 12.6V | | | 20 | 150 | µV/V |
| Load Regulation | $\Delta V_{OUT}/\Delta I_{OUT}$ | Sourcing: 0 ≤ $I_{OUT}$ ≤ 500µA | | | 0.14 | 0.60 | µV/µA |
| | | Sinking: -500µA ≤ $I_{OUT}$ ≤ 0 | | | 0.18 | 0.80 | |
| Dropout Voltage (Note 5) | $V_{IN}$ - $V_{OUT}$ | $I_{OUT}$ = 500µA | | | 100 | 200 | mV |
| OUT Short-Circuit Current | $I_{SC}$ | Short to GND | | | 4 | | mA |
| | | Short to IN | | | 4 | | |
| Temperature Hysteresis (Note 3) | | | | | 130 | | ppm |
| Long-Term Stability | $\Delta V_{OUT}$/time | 1000hr at $T_A$ = +25°C | | | 50 | | ppm/1000hr |
| **DYNAMIC** | | | | | | | |
| Noise Voltage | $e_{OUT}$ | f = 0.1Hz to 10Hz | | | 65 | | µVp-p |
| | | f = 10Hz to 10kHz | | | 150 | | $\mu V_{RMS}$ |
| Ripple Rejection | $\Delta V_{OUT}/\Delta V_{IN}$ | $V_{IN}$ = 5V ±100mV, f = 120Hz | | | 80 | | dB |
| Turn-On Settling Time | $t_R$ | To $V_{OUT}$ = 0.1% of final value, $C_{OUT}$ = 50pF | | | 100 | | µs |
| Capacitive-Load Stability Range | $C_{OUT}$ | Note 4 | | 0 | | 2.2 | nF |
| **INPUT** | | | | | | | |
| Supply Voltage Range | $V_{IN}$ | Guaranteed by line-regulation test | | $V_{OUT}$ + 0.2 | | 12.6 | V |
| Quiescent Supply Current | $I_{IN}$ | | | | 27 | 35 | µA |
| Change in Supply Current | $I_{IN}/V_{IN}$ | ($V_{OUT}$ + 0.2V) ≤ $V_{IN}$ ≤ 12.6V | | | 0.8 | 2.0 | µA/V |

# Precision, Low-Power, Low-Dropout, SOT23-3 Voltage References

## ELECTRICAL CHARACTERISTICS—MAX6041

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

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **OUTPUT** | | | | | | | |
| Output Voltage | $V_{OUT}$ | $T_A$ = +25°C | MAX6041A | 4.088 | 4.096 | 4.104 | V |
| | | | | -0.20 | | 0.20 | % |
| | | | MAX6041B | 4.080 | 4.096 | 4.112 | V |
| | | | | -0.39 | | 0.39 | % |
| Output Voltage Temperature Coefficient (Note 2) | $V_{OUT}$ | $T_A$ = 0°C to +70°C | MAX6041A | | 6 | 15 | ppm/°C |
| | | $T_A$ = -40°C to +85°C | | | 6 | 20 | |
| | | $T_A$ = 0°C to +70°C | MAX6041B | | 6 | 25 | |
| | | $T_A$ = -40°C to +85°C | | | 6 | 30 | |
| Line Regulation | $\Delta V_{OUT}/\Delta V_{IN}$ | ($V_{OUT}$ + 0.2V) ≤ $V_{IN}$ ≤ 12.6V | | | 25 | 160 | µV/V |
| Load Regulation | $\Delta V_{OUT}/\Delta I_{OUT}$ | Sourcing: 0 ≤ $I_{OUT}$ ≤ 500µA | | | 0.15 | 0.70 | µV/µA |
| | | Sinking: -500µA ≤ $I_{OUT}$ ≤ 0 | | | 0.20 | 0.90 | |
| Dropout Voltage (Note 5) | $V_{IN}$ - $V_{OUT}$ | $I_{OUT}$ = 500µA | | | 100 | 200 | mV |
| OUT Short-Circuit Current | $I_{SC}$ | Short to GND | | | 4 | | mA |
| | | Short to IN | | | 4 | | |
| Temperature Hysteresis (Note 3) | $\Delta V_{OUT}$/time | 1000hr at $T_A$ = +25°C | | | 130 | | ppm |
| Long-Term Stability | $\Delta V_{OUT}$/time | 1000hr at $T_A$ = +25°C | | | 50 | | ppm/1000hr |
| **DYNAMIC** | | | | | | | |
| Noise Voltage | $e_{OUT}$ | f = 0.1 Hz to 10Hz | | | 100 | | µVp-p |
| | | f = 10Hz to 10kHz | | | 200 | | $\mu V_{RMS}$ |
| Ripple Rejection | $\Delta V_{OUT}/\Delta V_{IN}$ | $V_{IN}$ = 5V ± 100mV, f = 120Hz | | | 77 | | dB |
| Turn-On Settling Time | $t_R$ | To $V_{OUT}$ = 0.1% of final value, $C_{OUT}$ = 50pF | | | 160 | | µs |
| Capacitive-Load Stability Range | $C_{OUT}$ | Note 4 | | 0 | | 2.2 | nF |
| **INPUT** | | | | | | | |
| Supply Voltage Range | $V_{IN}$ | Guaranteed by line-regulation test | | $V_{OUT}$ + 0.2 | | 12.6 | V |
| Quiescent Supply Current | $I_{IN}$ | | | | 27 | 35 | µA |
| Change in Supply Current | $I_{IN}/V_{IN}$ | ($V_{OUT}$ + 0.2V) ≤ $V_{IN}$ ≤ 12.6V | | | 0.8 | 2.0 | µA/V |

## ELECTRICAL CHARACTERISTICS—MAX6045

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

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **OUTPUT** | | | | | | | |
| Output Voltage | $V_{OUT}$ | $T_A$ = +25°C | MAX6045A | 4.491 | 4.500 | 4.509 | V |
| | | | | -0.20 | | 0.20 | % |
| | | | MAX6045B | 4.482 | 4.500 | 4.518 | V |
| | | | | -0.40 | | 0.40 | % |
| Output Voltage Temperature Coefficient (Note 2) | $V_{OUT}$ | $T_A$ = 0°C to +70°C | MAX6045A | | 6 | 15 | ppm/°C |
| | | $T_A$ = -40°C to +85°C | | | 6 | 20 | |
| | | $T_A$ = 0°C to +70°C | MAX6045B | | 6 | 25 | |
| | | $T_A$ = -40°C to +85°C | | | 6 | 30 | |
| Line Regulation | $\Delta V_{OUT}/\Delta V_{IN}$ | ($V_{OUT}$ + 0.2V) ≤ $V_{IN}$ ≤ 12.6V | | | 25 | 160 | µV/V |
| Load Regulation | $\Delta V_{OUT}/\Delta I_{OUT}$ | Sourcing: 0 ≤ $I_{OUT}$ ≤ 500µA | | | 0.16 | 0.80 | µV/µA |
| | | Sinking: -500µA ≤ $I_{OUT}$ ≤ 0 | | | 0.22 | 1.00 | |
| Dropout Voltage (Note 5) | $V_{IN}$ - $V_{OUT}$ | $I_{OUT}$ = 500µA | | | 100 | 200 | mV |
| OUT Short-Circuit Current | $I_{SC}$ | Short to GND | | | 4 | | mA |
| | | Short to IN | | | 4 | | |
| Temperature Hysteresis (Note 3) | $\Delta V_{OUT}$/time | | | | 130 | | ppm |
| Long-Term Stability | $\Delta V_{OUT}$/time | 1000hr at $T_A$ = +25°C | | | 50 | | ppm/1000hr |
| **DYNAMIC** | | | | | | | |
| Noise Voltage | $e_{OUT}$ | f = 0.1Hz to 10Hz | | | 110 | | µVp-p |
| | | f = 10Hz to 10kHz | | | 215 | | $\mu V_{RMS}$ |
| Ripple Rejection | $\Delta V_{OUT}/\Delta V_{IN}$ | $V_{IN}$ = 5V ±100mV, f = 120Hz | | | 76 | | dB |
| Turn-On Settling Time | $t_R$ | To $V_{OUT}$ = 0.1% of final value, $C_{OUT}$ = 50pF | | | 180 | | µs |
| Capacitive-Load Stability Range | $C_{OUT}$ | Note 4 | | 0 | | 2.2 | nF |
| **INPUT** | | | | | | | |
| Supply Voltage Range | $V_{IN}$ | Guaranteed by line-regulation test | | $V_{OUT}$ + 0.2 | | 12.6 | V |
| Quiescent Supply Current | $I_{IN}$ | | | | 27 | 35 | µA |
| Change in Supply Current | $I_{IN}/V_{IN}$ | ($V_{OUT}$ + 0.2V) ≤ $V_{IN}$ ≤ 12.6V | | | 0.8 | 2.0 | µA/V |

# Precision, Low-Power, Low-Dropout, SOT23-3 Voltage References

## ELECTRICAL CHARACTERISTICS—MAX6050

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

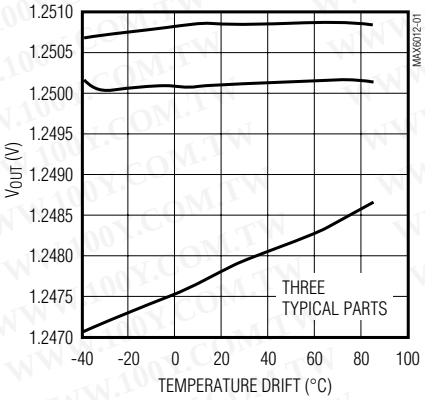
| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **OUTPUT** | | | | | | | |
| Output Voltage | $V_{OUT}$ | $T_A$ = +25°C | MAX6050A | 4.990 | 5.000 | 5.010 | V |
| | | | | -0.20 | | 0.20 | % |
| | | | MAX6050B | 4.980 | 5.000 | 5.020 | V |
| | | | | -0.40 | | 0.40 | % |
| Output Voltage Temperature Coefficient (Note 2) | $TCV_{OUT}$ | $T_A$ = 0°C to +70°C | MAX6050A | | 6 | 15 | ppm/°C |
| | | $T_A$ = -40°C to +85°C | | | 6 | 20 | |
| | | $T_A$ = 0°C to +70°C | MAX6050B | | 6 | 25 | |
| | | $T_A$ = -40°C to +85°C | | | 6 | 30 | |
| Line Regulation | $\Delta V_{OUT}/\Delta VIN$ | ($V_{OUT}$ + 0.2V) ≤ $V_{IN}$ ≤ 12.6V | | | 25 | 160 | µV/V |
| Load Regulation | $\Delta V_{OUT}/\Delta I_{OUT}$ | Sourcing: 0 ≤ $I_{OUT}$ ≤ 500µA | | | 0.17 | 0.85 | µV/µA |
| | | Sinking: -500µA ≤ $I_{OUT}$ ≤ 0 | | | 0.24 | 1.10 | |
| Dropout Voltage (Note 5) | $V_{IN}$ - $V_{OUT}$ | $I_{OUT}$ = 500µA | | | 100 | 200 | mV |
| OUT Short-Circuit Current | $I_{SC}$ | Short to GND | | | 4 | | mA |
| | | Short to IN | | | 4 | | |
| Temperature Hysteresis (Note 3) | | | | | 130 | | ppm |
| Long-Term Stability | $\Delta V_{OUT}$/time | 1000hr at $T_A$ = +25°C | | | 50 | | ppm/1000hr |
| **DYNAMIC** | | | | | | | |
| Noise Voltage | $e_{OUT}$ | f = 0.1 Hz to 10Hz | | | 120 | | µVp-p |
| | | f =10Hz to 10kHz | | | 240 | | $µV_{RMS}$ |
| Ripple Rejection | $\Delta V_{OUT}/\Delta V_{IN}$ | $V_{IN}$ = 5V ±100mV, f = 120Hz | | | 72 | | dB |
| Turn-On Settling Time | $t_R$ | To $V_{OUT}$ = 0.1% of final value, $C_{OUT}$ = 50pF | | | 220 | | µs |
| Capacitive-Load Stability Range | $C_{OUT}$ | Note 4 | | 0 | | 2.2 | nF |
| **INPUT** | | | | | | | |
| Supply Voltage Range | $V_{IN}$ | Guaranteed by line-regulation test | | $V_{OUT}$ + 0.2 | | 12.6 | V |
| Quiescent Supply Current | $I_{IN}$ | | | | 27 | 35 | µA |
| Change in Supply Current | $I_{IN}/V_{IN}$ | ($V_{OUT}$ + 0.2V) ≤ $V_{IN}$ ≤ 12.6V | | | 0.8 | 2.0 | µA/V |

**Note 1:** All devices are 100% production tested at $T_A$ = +25°C and are guaranteed by design for $T_A$ = $T_{MIN}$ to $T_{MAX}$, as specified.
**Note 2:** Temperature Coefficient is measured by the "box" method, i.e., the maximum $\Delta V_{OUT}$ is divided by the maximum $\Delta t$.
**Note 3:** Temperature Hysteresis is defined as the change in +25°C output voltage before and after cycling the device from $T_{MIN}$ to $T_{MAX}$.
**Note 4:** Not production tested. Guaranteed by design.
**Note 5:** Dropout voltage is the minimum input voltage at which $V_{OUT}$ changes ≤0.2% from $V_{OUT}$ at $V_{IN}$ = 5.0V ($V_{IN}$ = 5.5V for MAX6050).

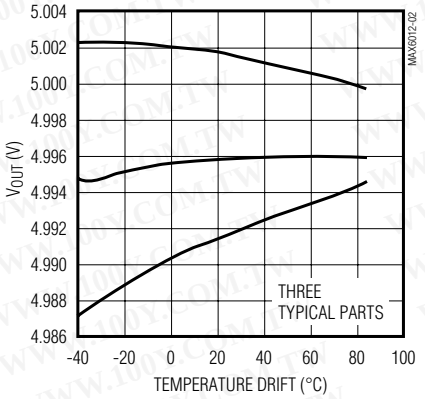
## Typical Operating Characteristics

($V_{IN}$ = +5V for MAX6012/21/25/30/41/45, $V_{IN}$ = +5.5V for MAX6050; $I_{OUT}$ = 0; $T_A$ = +25°C; unless otherwise noted.) (Note 6)

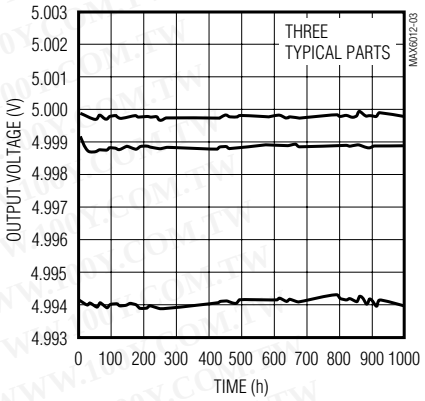
**MAX6012 OUTPUT VOLTAGE TEMPERATURE DRIFT**



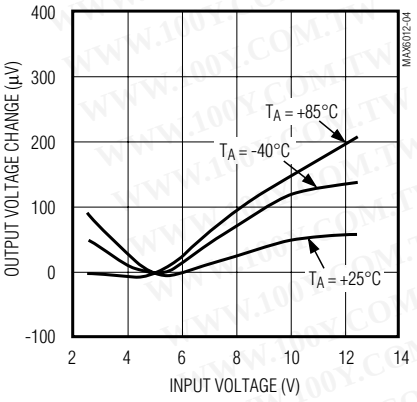

**MAX6050 OUTPUT VOLTAGE TEMPERATURE DRIFT**



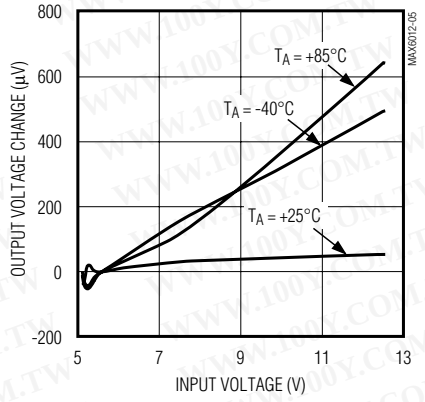

**MAX6050 LONG-TERM DRIFT**



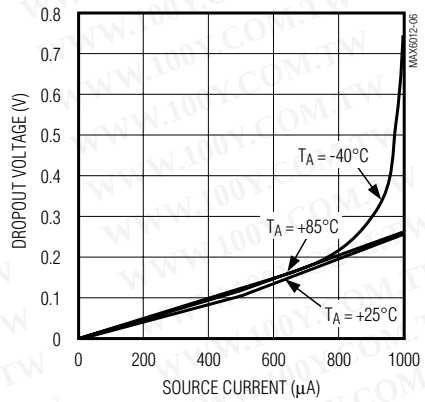

**MAX6012 LINE REGULATION**



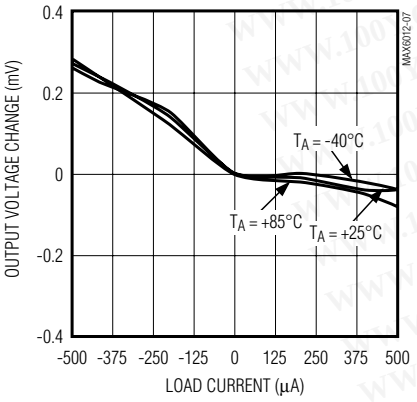

**MAX6050 LINE REGULATION**



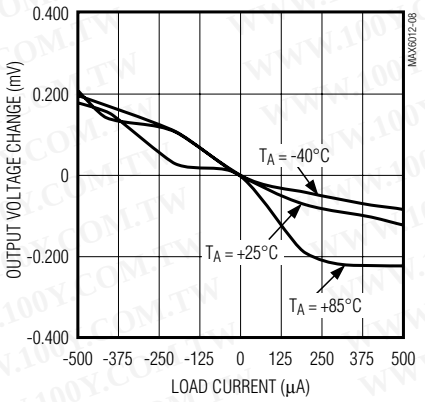

**MAX6025/MAX6030 DROPOUT VOLTAGE vs. SOURCE CURRENT**



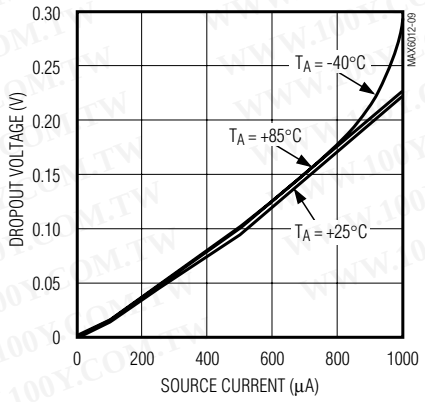

**MAX6012 LOAD REGULATION**




**MAX6050 LOAD REGULATION**




**MAX6041/MAX6045/MAX6050 DROPOUT VOLTAGE vs. SOURCE CURRENT**

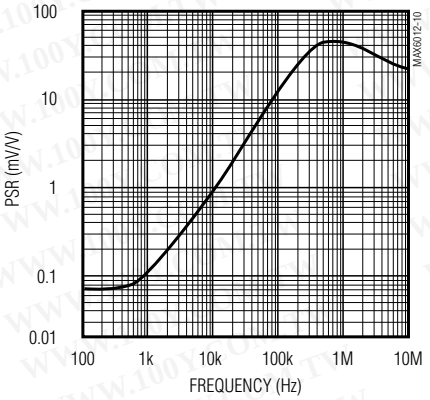


# Precision, Low-Power, Low-Dropout, SOT23-3 Voltage References

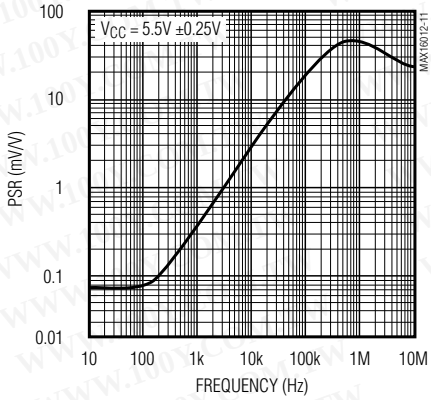
## Typical Operating Characteristics (continued)

($V_{IN}$ = +5V for MAX6012/21/25/30/41/45, $V_{IN}$ = +5.5V for MAX6050; $I_{OUT}$ = 0; $T_A$ = +25°C; unless otherwise noted.) (Note 6)

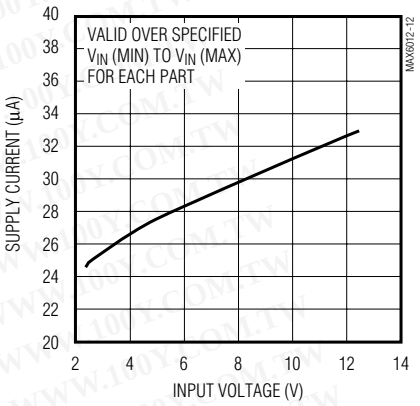
**MAX6012 POWER-SUPPLY REJECTION vs. FREQUENCY**



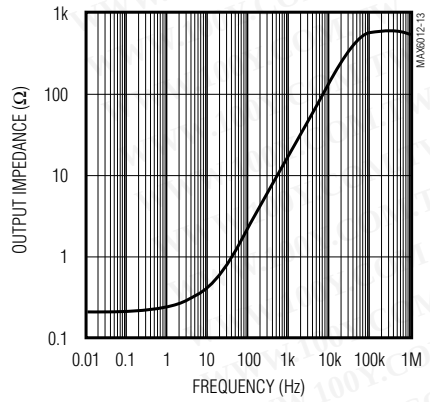

**MAX6050 POWER-SUPPLY REJECTION vs. FREQUENCY**



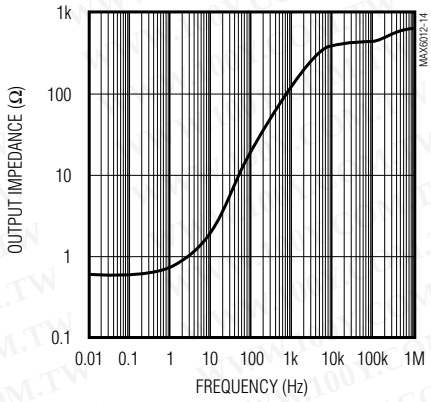

**SUPPLY CURRENT vs. INPUT VOLTAGE**



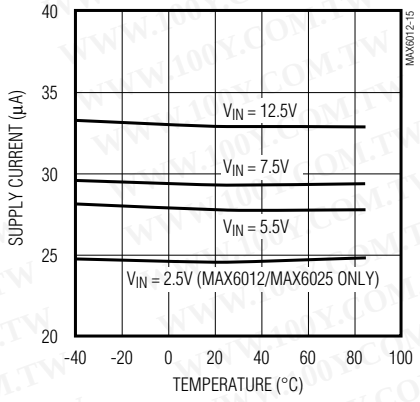

**MAX6012 OUTPUT IMPEDANCE vs. FREQUENCY**



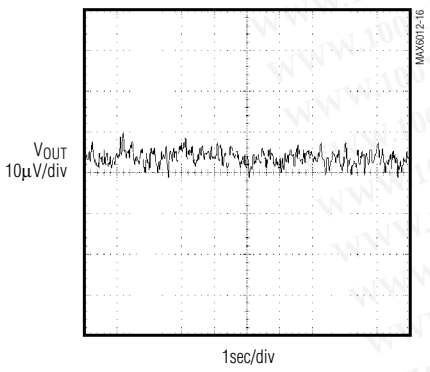

**MAX6050 OUTPUT IMPEDANCE vs. FREQUENCY**



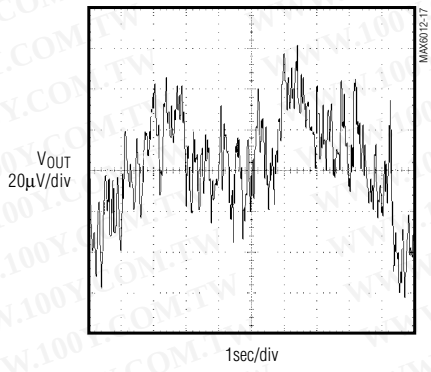

**SUPPLY CURRENT vs. TEMPERATURE**



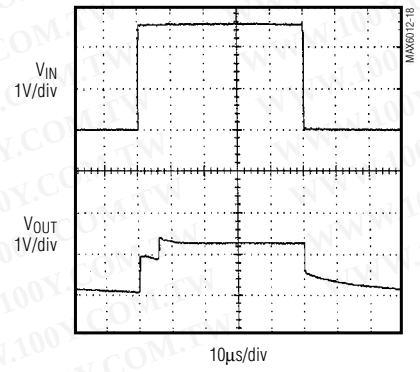

**MAX6012 0.1Hz TO 10Hz OUTPUT NOISE**




**MAX6050 0.1Hz TO 10Hz OUTPUT NOISE**



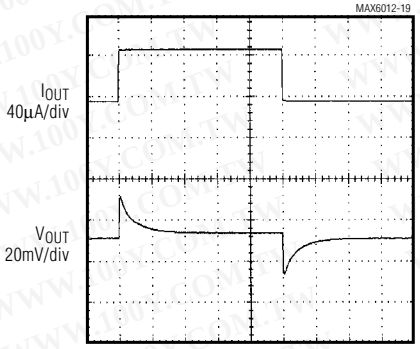

**MAX6012 TURN-ON TRANSIENT**



## Typical Operating Characteristics (continued)

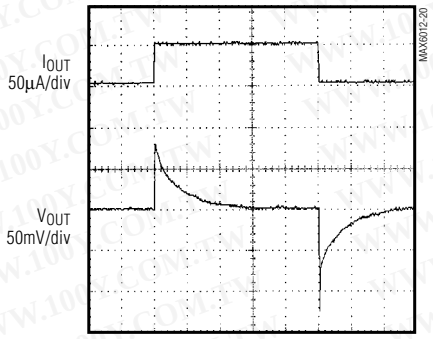
($V_{IN}$ = +5V for MAX6012/21/25/30/41/45, $V_{IN}$ = +5.5V for MAX6050; $I_{OUT}$ = 0; $T_A$ = +25°C; unless otherwise noted.) (Note 6)

**MAX6012**
**LOAD-TRANSIENT RESPONSE**



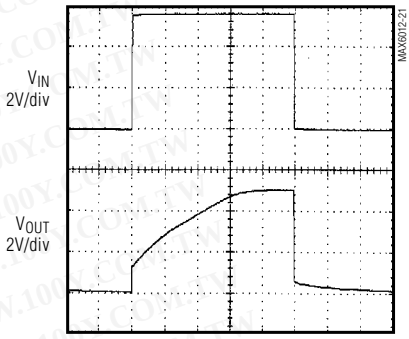

$I_{OUT}$ = ±25µA, AC-COUPLED

**MAX6050**
**LOAD-TRANSIENT RESPONSE**

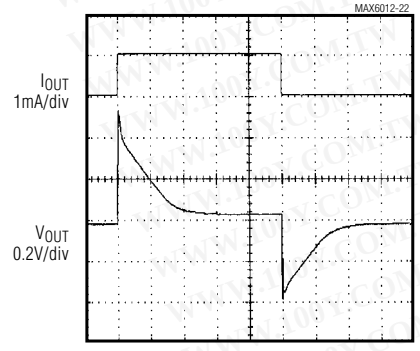



$V_{IN}$ = 5.5V, $I_{OUT}$ = ±25µA, AC-COUPLED

**MAX6050**
**TURN-ON TRANSIENT**

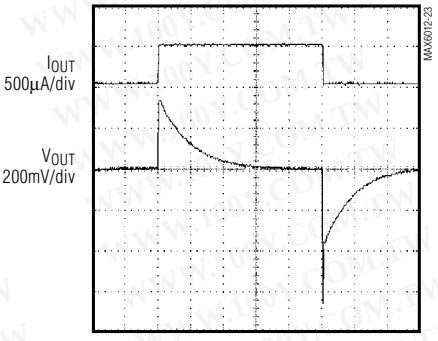



**MAX6012**
**LOAD-TRANSIENT RESPONSE**



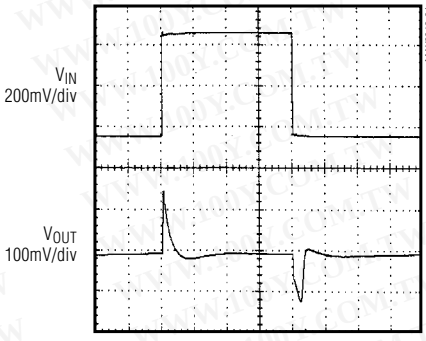

$I_{OUT}$ = ±500µA, AC-COUPLED

**MAX6050**
**LOAD-TRANSIENT RESPONSE**



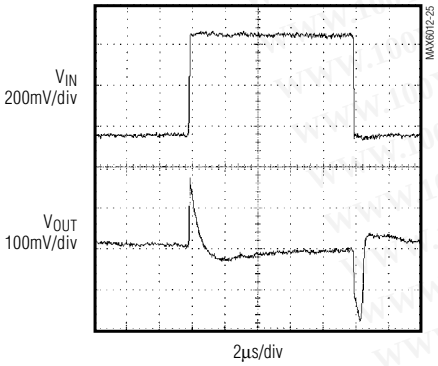

$V_{IN}$ = 5.5V, $I_{OUT}$ = ±500µA, AC-COUPLED

**MAX6012**
**LINE-TRANSIENT RESPONSE**




$V_{IN}$ = 5V ±0.25V, AC-COUPLED

**MAX6050**
**LINE-TRANSIENT RESPONSE**




$V_{IN}$ = 5.5V ±0.25V, AC-COUPLED

**Note 6:** Many of the *Typical Operating Characteristics* of the MAX6012 family are extremely similar. The extremes of these characteristics are found in the MAX6012 (1.2V output) and the MAX6050 (5.0V output). The *Typical Operating Characteristics* of the remainder of the MAX6012 family typically lie between these two extremes and can be estimated based on their output voltage.

# Precision, Low-Power, Low-Dropout, SOT23-3 Voltage References

## Pin Description

| PIN | NAME | FUNCTION |
|---|---|---|
| 1 | IN | Supply Voltage Input |
| 2 | OUT | Reference Voltage Output |
| 3 | GND | Ground |

## Detailed Description

The MAX6012/MAX6021/MAX6025/MAX6030/MAX6041/MAX6045/MAX6050 precision bandgap references use a proprietary curvature-correction circuit and laser-trimmed thin-film resistors, resulting in a low temperature coefficient of <20ppm/°C and initial accuracy of better than 0.2%. These devices can sink and source up to 500µA with <200mV of dropout voltage, making them attractive for use in low-voltage applications.

## Applications Information

### Output/Load Capacitance

Devices in this family do not require an output capacitance for frequency stability. They are stable for capacitive loads from 0 to 2.2nF. However, in applications where the load or the supply can experience step changes, an output capacitor will reduce the amount of overshoot (or undershoot) and assist the circuit's transient response. Many applications do not need an external capacitor, and this family can offer a significant advantage in these applications when board space is critical.

### Supply Current

The quiescent supply current of these series-mode references is a maximum of 35µA and is virtually independent of the supply voltage, with only a 0.8µA/V variation with supply voltage. Unlike series references, shunt-mode references operate with a series resistor connected to the power supply. The quiescent current of a shunt-mode reference is thus a function of the input voltage. Additionally, shunt-mode references have to be biased at the maximum expected load current, even if the load current is not present all the time. The load current is drawn from the input voltage only when required, so supply current is not wasted and efficiency is maximized at all input voltages. This improved efficiency can help reduce power dissipation and extend battery life.

When the supply voltage is below the minimum specified input voltage (as during turn-on), the devices can draw up to 200µA 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 130ppm.

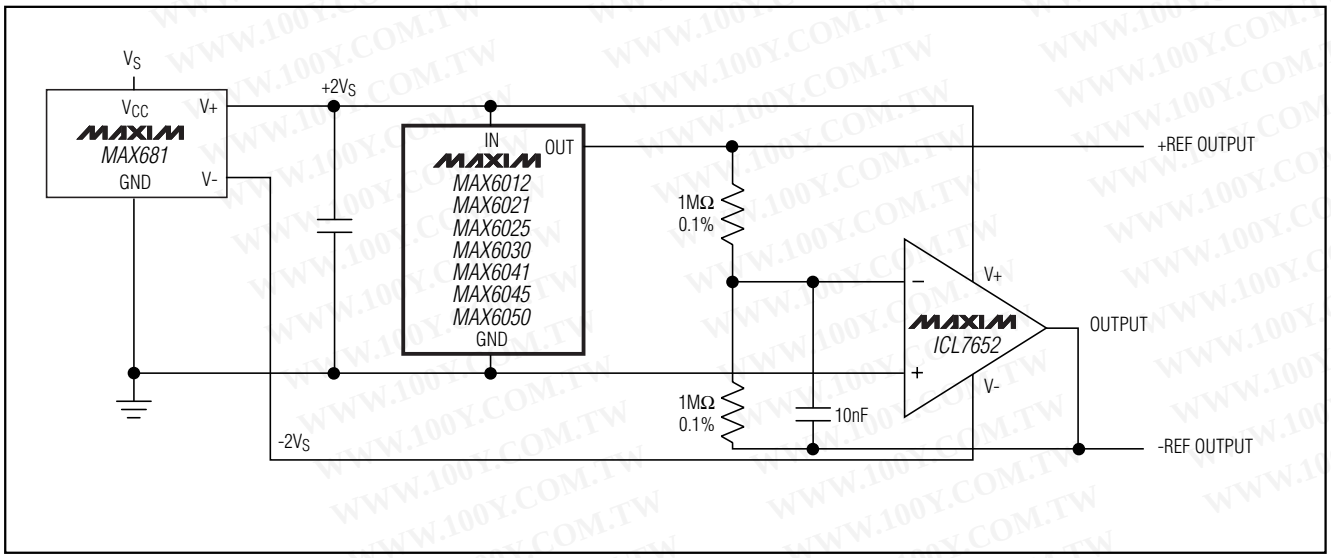



*Figure 1. Positive and Negative References from Single +3V or +5V Supply*

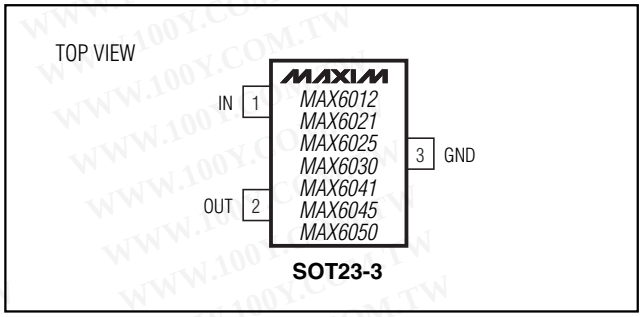
### Turn-On Time

These devices typically turn on and settle to within 0.1% of their final value; 30µs to 220µs depending on the device. The turn-on time can increase up to 1.5ms with the device operating at the minimum dropout voltage and the maximum load.

### Positive and Negative Low-Power Voltage Reference

Figure 1 shows a typical method for developing a bipolar reference. The circuit uses a MAX681 voltage doubler/inverter charge-pump converter to power an ICL7652, thus creating a positive as well as a negative reference voltage.

## Pin Configuration




## Chip Information

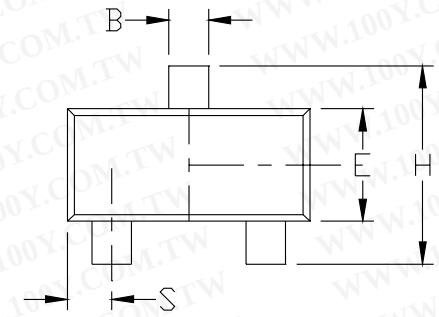
TRANSISTOR COUNT: 70

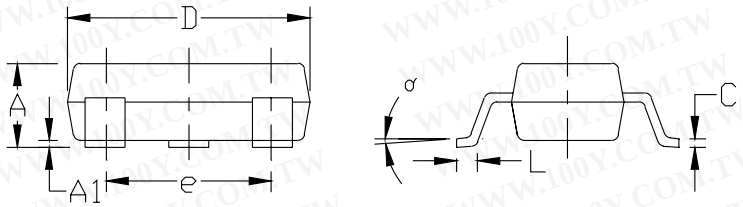
# Precision, Low-Power, Low-Dropout, SOT23-3 Voltage References

## Package Information

SOTP03L.EPS

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. CONTROLLING DIMENSION: MILLIMETER




| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 0.031 | 0.047 | 0.787 | 1.194 |
| A1 | 0.001 | 0.005 | 0.025 | 0.127 |
| B | 0.014 | 0.022 | 0.356 | 0.559 |
| C | 0.0034 | 0.006 | 0.086 | 0.152 |
| D | 0.105 | 0.120 | 2.667 | 3.048 |
| E | 0.047 | 0.055 | 1.194 | 1.397 |
| e | 0.070 | 0.080 | 1.778 | 2.032 |
| H | 0.082 | 0.098 | 2.083 | 2.489 |
| L | 0.004 | 0.012 | 0.102 | 0.305 |
| S | 0.017 | 0.022 | 0.432 | 0.559 |
| α | 0° | 8° | 0° | 8° |

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