



Precision, Low-Power, Low-Dropout, UCSP Voltage Reference

MAX6023

General Description

The MAX6023 is a family of low-dropout, micropower voltage references in a 5-bump, chip-scale package (UCSP™). The MAX6023 series-mode (three-terminal) references, which operate with input voltages from 2.5V to 12.6V (1.25V and 2.048V options) or ($V_{OUT} + 0.2V$) to 12.6V (all other voltage options), are available with output voltage options of 1.25V, 2.048V, 2.5V, 3.0V, 4.096V, 4.5V, and 5.0V. These devices are guaranteed an initial accuracy of $\pm 0.2\%$ and 30ppm/°C temperature drift over the -40°C to $+85^{\circ}\text{C}$ extended temperature range.

UCSPs offer the benefit of moving to smaller footprint and lower profile devices, significantly smaller than even SC70 or SOT23 plastic surface-mount packages. The significantly lower profile (compared to plastic SMD packages) of the UCSP makes the device ideal for height-critical applications. Miniature UCSP packages also enable device placement close to sources and allow more flexibility in a complex or large design layout.

The MAX6023 voltage references use only 27 μA of supply current. And unlike shunt-mode (two-terminal) references, the supply current of the MAX6023 family varies only 0.8 $\mu\text{A}/\text{V}$ with supply-voltage changes, translating to longer battery life. Additionally, these internally compensated devices do not require an external compensation capacitor and are stable up to 2.2nF of load capacitance. The low-dropout voltage and the low supply current make these devices ideal for battery-operated systems.

Applications

Hand-Held Equipment
Data Acquisition Systems
Industrial and Process Control Systems
Battery-Operated Equipment
Hard-Disk Drives

Selector Guide

| PART | V_{OUT} (V) | INPUT VOLTAGE (V) |
|--------------|---------------|--------------------------------------|
| MAX6023EBT12 | 1.250 | 2.5V to 12.6 |
| MAX6023EBT21 | 2.048 | 2.5V to 12.6 |
| MAX6023EBT25 | 2.500 | ($V_{OUT} + 200\text{mV}$) to 12.6 |
| MAX6023EBT30 | 3.000 | ($V_{OUT} + 200\text{mV}$) to 12.6 |
| MAX6023EBT41 | 4.096 | ($V_{OUT} + 200\text{mV}$) to 12.6 |
| MAX6023EBT45 | 4.500 | ($V_{OUT} + 200\text{mV}$) to 12.6 |
| MAX6023EBT50 | 5.000 | ($V_{OUT} + 200\text{mV}$) to 12.6 |

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For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

Features

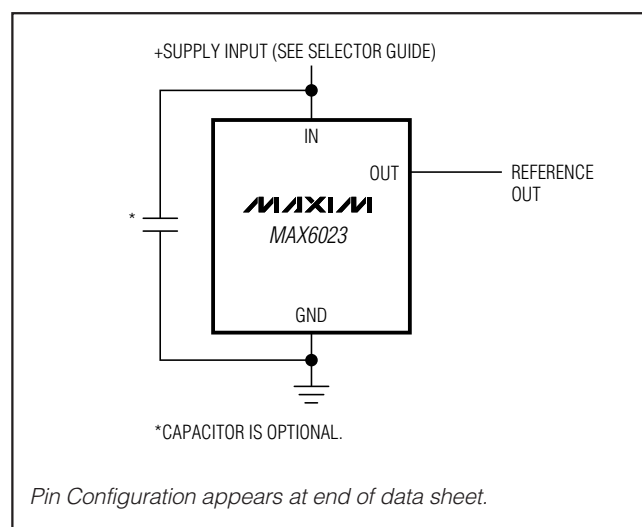
- ◆ 5-Bump UCSP Package (1.0mm × 1.5mm × 0.3mm)
- ◆ No Output Capacitor Needed
- ◆ $\pm 0.2\%$ (max) Initial Accuracy
- ◆ 30ppm/°C (max) Temperature Coefficient
- ◆ 35 μA (max) Quiescent Supply Current
- ◆ 0.8 $\mu\text{A}/\text{V}$ (max) Supply Current Variation with V_{IN}
- ◆ 100mV Dropout at 500 μA Load Current
- ◆ Line Regulation: 160 $\mu\text{V}/\text{V}$ (max)
- ◆ Output Voltage Options: 1.25V, 2.048V, 2.5V, 3.0V, 4.096V, 4.5V, 5.0V

Ordering Information

| PART | TEMP RANGE | BUMP-PACKAGE | TOP MARK |
|----------------|--|--------------|----------|
| MAX6023EBT12-T | -40°C to $+85^{\circ}\text{C}$ | 5 UCSP*-5 | AAO |
| MAX6023EBT21-T | -40°C to $+85^{\circ}\text{C}$ | 5 UCSP-5 | AAT |
| MAX6023EBT25-T | -40°C to $+85^{\circ}\text{C}$ | 5 UCSP-5 | AAP |
| MAX6023EBT30-T | -40°C to $+85^{\circ}\text{C}$ | 5 UCSP-5 | AAS |
| MAX6023EBT41-T | -40°C to $+85^{\circ}\text{C}$ | 5 UCSP-5 | AAQ |
| MAX6023EBT45-T | -40°C to $+85^{\circ}\text{C}$ | 5 UCSP-5 | AAR |
| MAX6023EBT50-T | -40°C to $+85^{\circ}\text{C}$ | 5 UCSP-5 | AAU |

*UCSP reliability is integrally linked to the user's assembly methods, circuit board material, and environment. See the UCSP Reliability Notice in the UCSP Reliability section of this data sheet for more information.

Typical Operating Circuit



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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 ($V_{IN} \geq 6V$) | 60s |

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

| | |
|--|---|
| 5-Bump UCSP (derate 3.4mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$)..... | 273mW |
| Operating Temperature Range | -40°C to $+85^\circ\text{C}$ |
| Storage Temperature Range | -65°C to $+150^\circ\text{C}$ |
| Bump Temperature (soldering, 10s)..... | $+300^\circ\text{C}$ |

Note 1: This device is constructed using a unique set of packaging techniques that impose a limit on the thermal profile the device can be exposed to during board-level solder attach and rework. This limit permits only the use of solder profiles recommended in the industry-standard specification, JEDEC 020A, paragraph 7.6, Table 3 for IR/VPR and convection reflow. Preheating is required. Hand or wave soldering is not allowed.

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—MAX6023EBT12 ($V_{OUT} = 1.250V$)

($V_{IN} = +5V$, $I_{OUT} = 0$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ\text{C}$.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|---|--|-------|-------|-------|---------------------------|
| OUTPUT | | | | | | |
| Output Voltage | V_{OUT} | $T_A = +25^\circ\text{C}$ | 1.247 | 1.250 | 1.253 | V |
| Initial Voltage Accuracy | | $T_A = +25^\circ\text{C}$ | -0.24 | | +0.24 | % |
| Output Voltage Temperature Coefficient | | (Note 3) | | 10 | 30 | ppm/ $^\circ\text{C}$ |
| Line Regulation | $\frac{\Delta V_{OUT}}{\Delta V_{IN}}$ | $2.5V \leq V_{IN} \leq 12.6V$ | | 10 | 80 | $\mu\text{V}/\text{V}$ |
| Load Regulation | $\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$ | $0 \leq I_{OUT} \leq 400\mu\text{A}$ | | 0.4 | 1.0 | $\mu\text{V}/\mu\text{A}$ |
| | | $-400\mu\text{A} \leq I_{OUT} \leq 0$ | | 0.5 | 1.1 | |
| Short-Circuit Current | I_{SC} | Short to GND | | 4 | | mA |
| | | Short to IN | | 10 | | |
| Temperature Hysteresis | | (Note 4) | | 90 | | ppm |
| Long-Term Stability | $\frac{\Delta V_{OUT}}{\text{time}}$ | 1000hr at $T_A = +25^\circ\text{C}$ | | 30 | | ppm/ 1000hr |
| DYNAMIC CHARACTERISTICS | | | | | | |
| Noise Voltage | e_{OUT} | $f = 0.1\text{Hz}$ to 10Hz | | 25 | | $\mu\text{Vp-p}$ |
| | | $f = 10\text{Hz}$ to 10kHz | | 65 | | μV_{RMS} |
| Ripple Rejection | $\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$ | $V_{IN} = +5V \pm 100\text{mV}$, $f = 120\text{Hz}$ | | 86 | | dB |
| Turn-On Settling Time | t_R | To V_{OUT} within 0.1% of final value, $C_{OUT} = 50\text{pF}$ | | 30 | | μs |
| Capacitive-Load Stability Range | C_{OUT} | (Note 3) | 0 | | 2.2 | nF |
| INPUT | | | | | | |
| Supply-Voltage Range | V_{IN} | Guaranteed by line-regulation test | 2.5 | | 12.6 | V |
| Supply Current | I_{IN} | | | 27 | 35 | μA |
| Change in Supply Current | $\Delta I_{IN}/\Delta V_{IN}$ | $2.5V \leq V_{IN} \leq 12.6V$ | | 0.8 | 2.0 | $\mu\text{A}/\text{V}$ |

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ELECTRICAL CHARACTERISTICS—MAX6023EBT21 (V_{OUT} = 2.048V)

(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 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|---|---|-------|-------|-------|-------------------|
| OUTPUT | | | | | | |
| Output Voltage | V _{OUT} | T _A = +25°C | 2.044 | 2.048 | 2.052 | V |
| Initial Voltage Accuracy | | T _A = +25°C | -0.20 | | +0.20 | % |
| Output Voltage Temperature Coefficient | | (Note 3) | | 10 | 30 | ppm/°C |
| Line Regulation | $\frac{\Delta V_{OUT}}{\Delta V_{IN}}$ | 2.5V ≤ V _{IN} ≤ 12.6V | | 20 | 100 | μV/V |
| Load Regulation | $\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$ | 0 ≤ I _{OUT} ≤ 500μA | | 0.5 | 1.4 | μV/μA |
| | | -500μA ≤ I _{OUT} ≤ 0 | | 0.3 | 0.70 | |
| Short-Circuit Current | I _{SC} | Short to GND | | 4 | | mA |
| | | Short to IN | | 10 | | |
| Temperature Hysteresis | | (Note 4) | | 90 | | ppm |
| Long-Term Stability | $\frac{\Delta V_{OUT}}{\text{time}}$ | 1000hr at T _A = +25°C | | 50 | | ppm/1000hr |
| DYNAMIC CHARACTERISTICS | | | | | | |
| Noise Voltage | e _{OUT} | f = 0.1Hz to 10Hz | | 40 | | μVp-p |
| | | f = 10Hz to 10kHz | | 105 | | μV _{RMS} |
| Ripple Rejection | $\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$ | V _{IN} = +5V ±100mV, f = 120Hz | | 82 | | dB |
| Turn-On Settling Time | t _R | To V _{OUT} within 0.1% of final value, C _{OUT} = 50pF | | 85 | | μs |
| Capacitive-Load Stability Range | C _{OUT} | (Note 3) | 0 | | 2.2 | nF |
| INPUT | | | | | | |
| Supply-Voltage Range | V _{IN} | Guaranteed by line-regulation test | 2.5 | | 12.6 | V |
| Supply Current | I _{IN} | | | 27 | 35 | μA |
| Change in Supply Current | $\Delta I_{IN}/\Delta V_{IN}$ | 2.5V ≤ V _{IN} ≤ 12.6V | | 0.8 | 2.0 | μA/V |

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ELECTRICAL CHARACTERISTICS—MAX6023EBT25 ($V_{OUT} = 2.500V$)

($V_{IN} = +5V$, $I_{OUT} = 0$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|---|--|-----------------|-----|-------|-----------------|
| OUTPUT | | | | | | |
| Output Voltage | V_{OUT} | $T_A = +25^\circ C$ | 2.495 | 2.5 | 2.505 | V |
| Initial Voltage Accuracy | | $T_A = +25^\circ C$ | -0.20 | | +0.20 | % |
| Output Voltage Temperature Coefficient | | (Note 3) | | 10 | 30 | ppm/ $^\circ C$ |
| Line Regulation | $\frac{\Delta V_{OUT}}{\Delta V_{IN}}$ | $(V_{OUT} + 0.2V) \leq V_{IN} \leq 12.6V$ | | 25 | 140 | $\mu V/V$ |
| Load Regulation | $\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$ | $0 \leq I_{OUT} \leq 500\mu A$ | | 0.5 | 1.4 | $\mu V/\mu A$ |
| | | $-500\mu A \leq I_{OUT} \leq 0$ | | 0.3 | 0.8 | |
| Short-Circuit Current | I_{SC} | Short to GND | | 4 | | mA |
| | | Short to IN | | 10 | | |
| Dropout Voltage | $(V_{IN} - V_{OUT})$ | $I_{OUT} = 500\mu A$ (Note 5) | | 100 | 200 | mV |
| Temperature Hysteresis | | (Note 4) | | 90 | | ppm |
| Long-Term Stability | $\frac{\Delta V_{OUT}}{\text{time}}$ | 1000hr at $T_A = +25^\circ C$ | | 50 | | ppm/1000hr |
| DYNAMIC CHARACTERISTICS | | | | | | |
| Noise Voltage | e_{OUT} | $f = 0.1\text{Hz to } 10\text{Hz}$ | | 60 | | μV_{p-p} |
| | | $f = 10\text{Hz to } 10\text{kHz}$ | | 125 | | μV_{RMS} |
| Ripple Rejection | $\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$ | $V_{IN} = +5V \pm 100\text{mV}$, $f = 120\text{Hz}$ | | 82 | | dB |
| Turn-On Settling Time | t_R | To V_{OUT} within 0.1% of final value, $C_{OUT} = 50\text{pF}$ | | 85 | | μs |
| Capacitive-Load Stability Range | C_{OUT} | (Note 3) | 0 | | 2.2 | nF |
| INPUT | | | | | | |
| Supply-Voltage Range | V_{IN} | Guaranteed by line-regulation test | $V_{OUT} + 0.2$ | | 12.6 | V |
| Supply Current | I_{IN} | | | 27 | 35 | μA |
| Change in Supply Current | $\Delta I_{IN}/\Delta V_{IN}$ | $(V_{OUT} + 0.2V) \leq V_{IN} \leq 12.6V$ | | 0.8 | 2.0 | $\mu A/V$ |

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ELECTRICAL CHARACTERISTICS—MAX6023EBT30 (V_{OUT} = 3.000V)

(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 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|---|---|-------|------------------------|-------|-------------------|
| Output Voltage | V _{OUT} | T _A = +25°C | 2.994 | 3.000 | 3.006 | V |
| Initial Voltage Accuracy | | T _A = +25°C | -0.20 | | +0.20 | % |
| Output Voltage Temperature Coefficient | | (Note 3) | | 10 | 30 | ppm/°C |
| Line Regulation | $\frac{\Delta V_{OUT}}{\Delta V_{IN}}$ | (V _{OUT} + 0.2V) ≤ V _{IN} ≤ 12.6V | | 40 | 140 | μV/V |
| Load Regulation | $\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$ | 0 ≤ I _{OUT} ≤ 500μA | | 0.7 | 1.5 | μV/μA |
| | | -500μA ≤ I _{OUT} ≤ 0 | | 0.4 | 0.8 | |
| Dropout Voltage | (V _{IN} - V _{OUT}) | I _{OUT} = 500μA (Note 5) | | 100 | 200 | mV |
| Short-Circuit Current | I _{SC} | Short to GND | | 4 | | mA |
| | | Short to IN | | 10 | | |
| Temperature Hysteresis | | (Note 4) | | 90 | | ppm |
| Long-Term Stability | $\frac{\Delta V_{OUT}}{\text{time}}$ | 1000hr at T _A = +25°C | | 50 | | ppm/1000hr |
| DYNAMIC CHARACTERISTICS | | | | | | |
| Noise Voltage | e _{OUT} | f = 0.1Hz to 10Hz | | 75 | | μVp-p |
| | | f = 10Hz to 10kHz | | 150 | | μV _{RMS} |
| Ripple Rejection | $\frac{\Delta V_{OUT}}{\Delta V_{IN}}$ | V _{IN} = +5V ±100mV, f = 120Hz | | 82 | | dB |
| Turn-On Settling Time | t _R | To V _{OUT} within 0.1% of final value, C _{OUT} = 50pF | | 85 | | μs |
| Capacitive-Load Stability Range | C _{OUT} | (Note 3) | 0 | | 2.2 | nF |
| INPUT | | | | | | |
| Supply-Voltage Range | V _{IN} | Guaranteed by line-regulation test | | V _{OUT} + 0.2 | 12.6 | V |
| Supply Current | I _{IN} | | | 27 | 35 | μA |
| Change in Supply Current | $\frac{\Delta I_{IN}}{\Delta V_{IN}}$ | (V _{OUT} + 0.2V) ≤ V _{IN} ≤ 12.6V | | 0.8 | 2.0 | μA/V |

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ELECTRICAL CHARACTERISTICS—MAX6023EBT41 (V_{OUT} = 4.096V)

(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 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|---|---|------------------------|-------|-------|------------|
| OUTPUT | | | | | | |
| Output Voltage | V _{OUT} | T _A = +25°C | 4.088 | 4.096 | 4.104 | V |
| Initial Voltage Accuracy | | T _A = +25°C | -0.20 | | +0.20 | % |
| Output Voltage Temperature Coefficient | | (Note 3) | | 10 | 30 | ppm/°C |
| Line Regulation | $\frac{\Delta V_{OUT}}{\Delta V_{IN}}$ | (V _{OUT} + 0.2V) ≤ V _{IN} ≤ 12.6V | | 50 | 160 | μV/V |
| Load Regulation | $\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$ | 0 ≤ I _{OUT} ≤ 500μA | | 1.0 | 1.8 | μV/μA |
| | | -500μA ≤ I _{OUT} ≤ 0 | | 0.3 | 0.9 | |
| Dropout Voltage | (V _{IN} - V _{OUT}) | I _{OUT} = 500μA (Note 5) | | 100 | 200 | mV |
| Short-Circuit Current | I _{SC} | Short to GND | | 4 | | mA |
| | | Short to IN | | 10 | | |
| Temperature Hysteresis | | (Note 4) | | 90 | | ppm |
| Long-Term Stability | $\frac{\Delta V_{OUT}}{\text{time}}$ | 1000hr at T _A = +25°C | | 50 | | ppm/1000hr |
| DYNAMIC CHARACTERISTICS | | | | | | |
| Noise Voltage | e _{OUT} | f = 0.1Hz to 10Hz | | 100 | | μVp-p |
| | | f = 10Hz to 10kHz | | 200 | | μVRMS |
| Ripple Rejection | $\frac{\Delta V_{OUT}}{\Delta V_{IN}}$ | V _{IN} = +5V ±100mV, f = 120Hz | | 77 | | dB |
| Turn-On Settling Time | t _R | To V _{OUT} within 0.1% of final value, C _{OUT} = 50pF | | 160 | | μs |
| Capacitive-Load Stability Range | C _{OUT} | (Note 3) | 0 | | 2.2 | nF |
| INPUT | | | | | | |
| Supply-Voltage Range | V _{IN} | Guaranteed by line-regulation test | V _{OUT} + 0.2 | | 12.6 | V |
| Supply Current | I _{IN} | | | 27 | 35 | μA |
| Change in Supply Current | $\Delta I_{IN}/\Delta V_{IN}$ | (V _{OUT} + 0.2V) ≤ V _{IN} ≤ 12.6V | | 0.8 | 2.0 | μA/V |

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ELECTRICAL CHARACTERISTICS—MAX6023EBT45 (V_{OUT} = 4.500V)

(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 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|---|---|------------------------|-------|-------|------------|
| OUTPUT | | | | | | |
| Output Voltage | V _{OUT} | T _A = +25°C | 4.491 | 4.500 | 4.509 | V |
| Initial Voltage Accuracy | | T _A = +25°C | -0.20 | | +0.20 | % |
| Output Voltage Temperature Coefficient | | (Note 3) | | 10 | 30 | ppm/°C |
| Line Regulation | $\frac{\Delta V_{OUT}}{\Delta V_{IN}}$ | (V _{OUT} + 0.2V) ≤ V _{IN} ≤ 12.6V | | 50 | 160 | μV/V |
| Load Regulation | $\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$ | 0 ≤ I _{OUT} ≤ 500μA | | 1.0 | 2.0 | μV/μA |
| | | -500μA ≤ I _{OUT} ≤ 0 | | 0.3 | 1.0 | |
| Dropout Voltage | (V _{IN} - V _{OUT}) | I _{OUT} = 500μA (Note 5) | | 100 | 200 | mV |
| Short-Circuit Current | I _{SC} | Short to GND | | 4 | | mA |
| | | Short to IN | | 10 | | |
| Temperature Hysteresis | | (Note 4) | | 90 | | ppm |
| Long-Term Stability | $\frac{\Delta V_{OUT}}{\text{time}}$ | 1000hr at T _A = +25°C | | 50 | | ppm/1000hr |
| DYNAMIC CHARACTERISTICS | | | | | | |
| Noise Voltage | e _{OUT} | f = 0.1Hz to 10Hz | | 110 | | μVp-p |
| | | f = 10Hz to 10kHz | | 215 | | μVRMS |
| Ripple Rejection | $\frac{\Delta V_{OUT}}{\Delta V_{IN}}$ | V _{IN} = +5V ±100mV, f = 120Hz | | 82 | | dB |
| Turn-On Settling Time | t _R | To V _{OUT} within 0.1% of final value, C _{OUT} = 50pF | | 85 | | μs |
| Capacitive-Load Stability Range | C _{OUT} | (Note 3) | 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 | $\Delta I_{IN}/\Delta V_{IN}$ | (V _{OUT} + 0.2V) ≤ V _{IN} ≤ 12.6V | | 0.8 | 2.0 | μA/V |

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ELECTRICAL CHARACTERISTICS—MAX6023EBT50 (V_{OUT} = 5.000V)

(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 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|---|---|-------|------------------------|-------|------------|
| Output Voltage | V _{OUT} | T _A = +25°C | 4.990 | 5.0 | 5.010 | V |
| Initial Voltage Accuracy | | T _A = +25°C | -0.20 | | +0.20 | % |
| Output Voltage Temperature Coefficient | | (Note 3) | | 10 | 30 | ppm/°C |
| Line Regulation | $\frac{\Delta V_{OUT}}{\Delta V_{IN}}$ | (V _{OUT} + 0.2V) ≤ V _{IN} ≤ 12.6V | | 50 | 160 | μV/V |
| Load Regulation | $\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$ | 0 ≤ I _{OUT} ≤ 500μA | | 1.2 | 2.2 | μV/μA |
| | | -500μA ≤ I _{OUT} ≤ 0 | | 0.3 | 1.1 | |
| Dropout Voltage | (V _{IN} - V _{OUT}) | I _{OUT} = 500μA (Note 5) | | 100 | 200 | mV |
| Short-Circuit Current | I _{SC} | Short to GND | | 4 | | mA |
| | | Short to IN | | 10 | | |
| Temperature Hysteresis | | (Note 4) | | 90 | | ppm |
| Long-Term Stability | $\frac{\Delta V_{OUT}}{\text{time}}$ | 1000hr at T _A = +25°C | | 50 | | ppm/1000hr |
| DYNAMIC CHARACTERISTICS | | | | | | |
| Noise Voltage | e _{OUT} | f = 0.1Hz to 10Hz | | 120 | | μVp-p |
| | | f = 10Hz to 10kHz | | 240 | | μVRMS |
| Ripple Rejection | $\frac{\Delta V_{OUT}}{\Delta V_{IN}}$ | V _{IN} = +5V ±100mV, f = 120Hz | | 72 | | dB |
| Turn-On Settling Time | t _R | To V _{OUT} within 0.1% of final value, C _{OUT} = 50pF | | 220 | | μs |
| Capacitive-Load Stability Range | C _{OUT} | (Note 3) | 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 | $\Delta I_{IN}/\Delta V_{IN}$ | 2.5V ≤ V _{IN} ≤ 12.6V | | 0.9 | 2.0 | μA/V |

Note 2: Devices are 100% production tested at T_A = +25°C and are guaranteed by design from T_A = T_{MIN} to T_{MAX}.

Note 3: Guaranteed by design.

Note 4: Temperature hysteresis is defined as the change in T_A = +25°C output voltage before and after temperature cycling of the device from T_A = T_{MIN} to T_{MAX}.

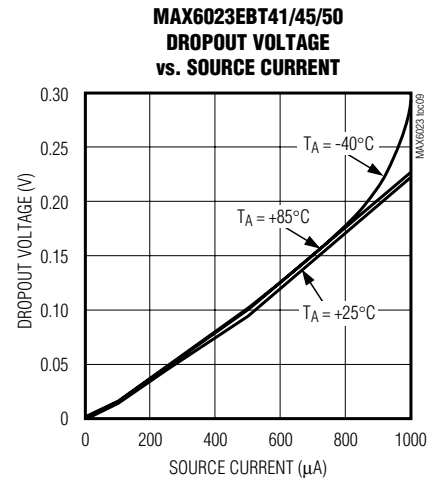
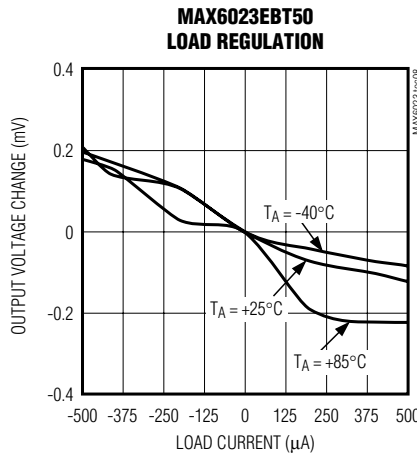
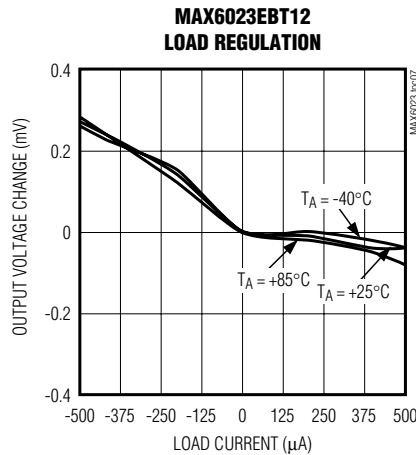
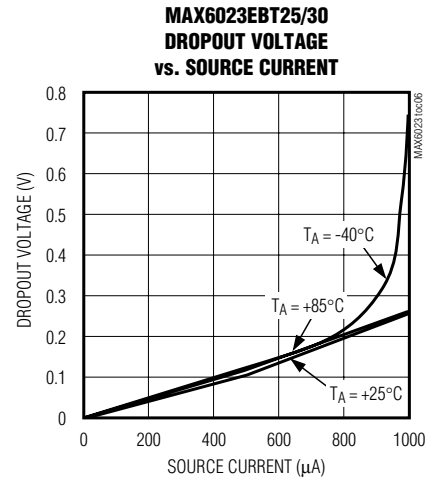
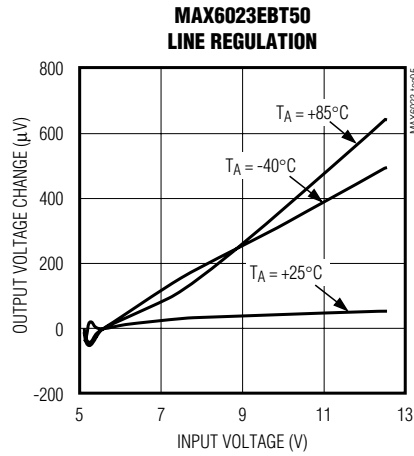
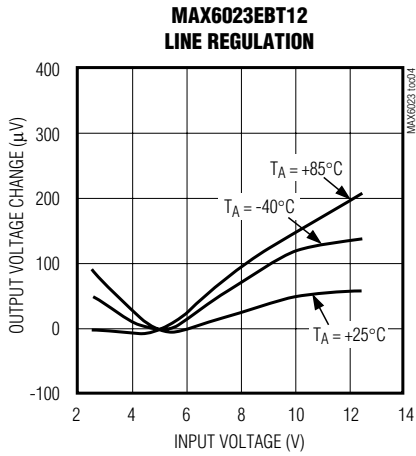
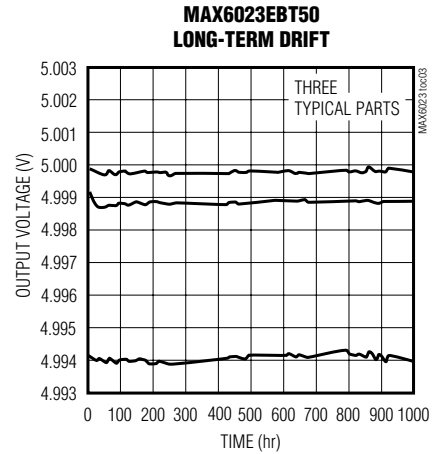
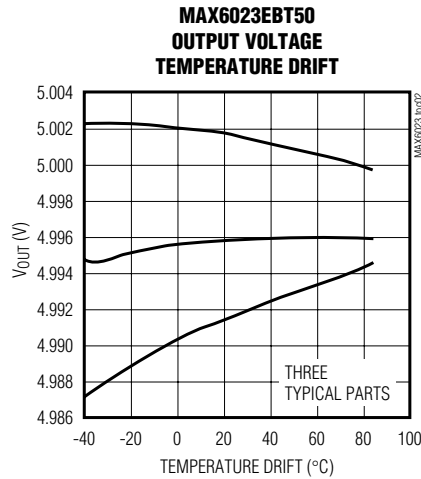
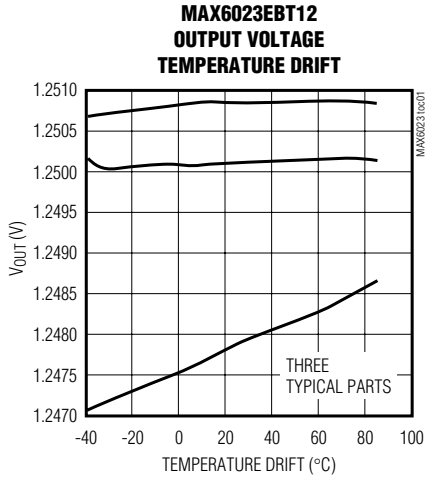
Note 5: Dropout voltage is the minimum input voltage at which V_{OUT} changes ≤ 0.2% from V_{OUT} at V_{IN} = +5.0V (V_{IN} = +5.5V for MAX6023EBT50).

Precision, Low-Power, Low-Dropout, UCSP Voltage Reference

MAX6023

Typical Operating Characteristics

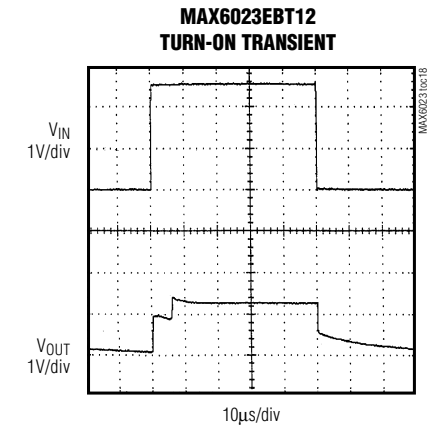
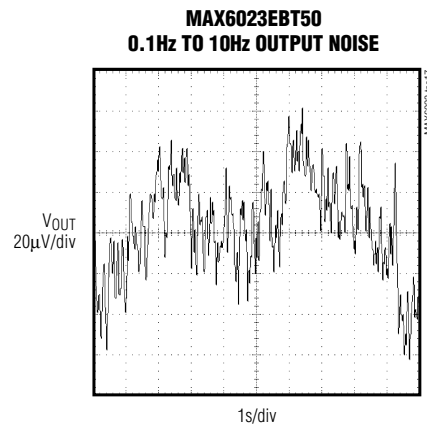
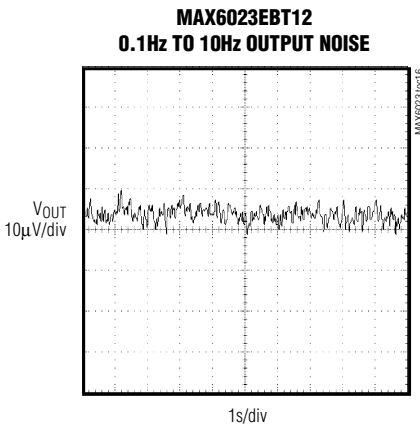
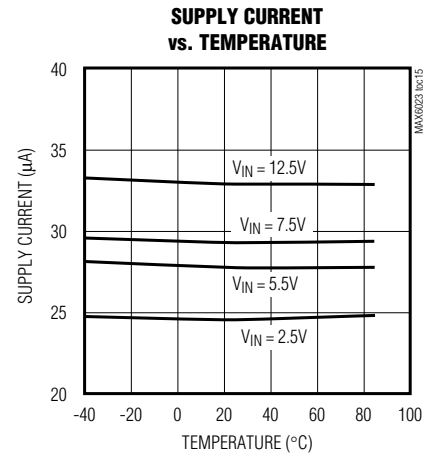
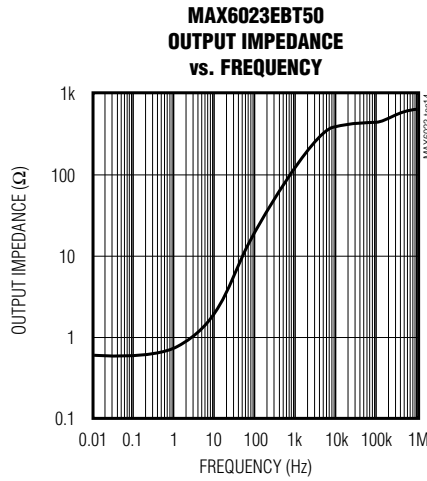
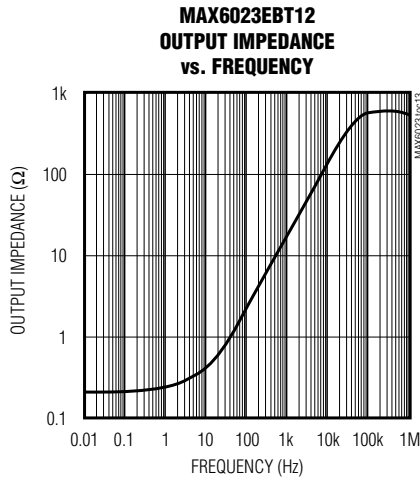
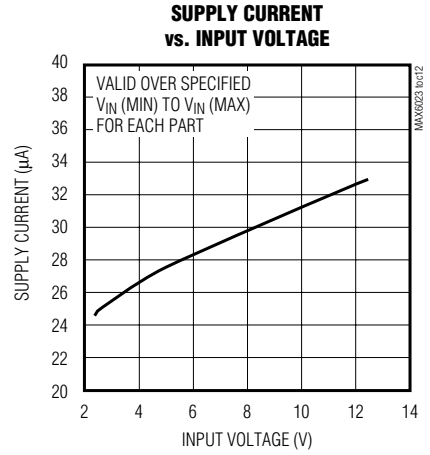
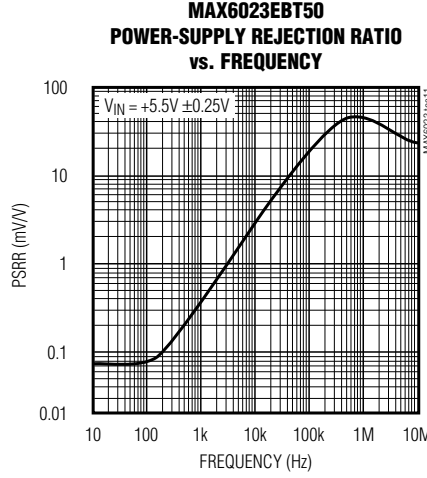
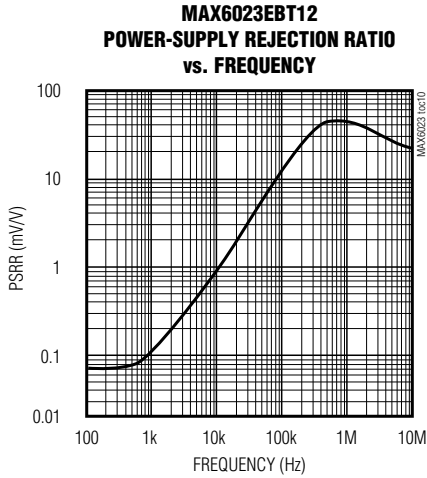
($V_{IN} = +5V$ for MAX6023EBT12/21/25/30/41/45, $V_{IN} = +5.5V$ for MAX6023EBT50; $I_{OUT} = 0$; $T_A = +25^\circ C$, unless otherwise noted.) (Note 6)



Precision, Low-Power, Low-Dropout, UCSP Voltage Reference

Typical Operating Characteristics (continued)

($V_{IN} = +5V$ for MAX6023EBT12/21/25/30/41/45, $V_{IN} = +5.5V$ for MAX6023EBT50; $I_{OUT} = 0$; $T_A = +25^\circ C$, unless otherwise noted.) (Note 6)

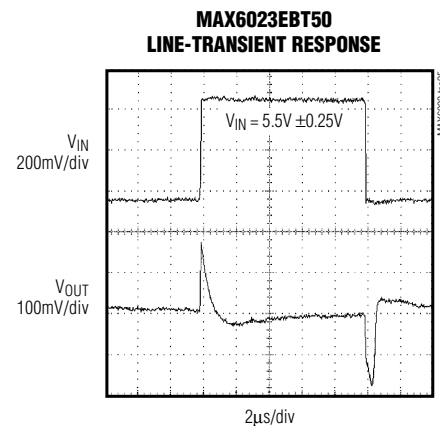
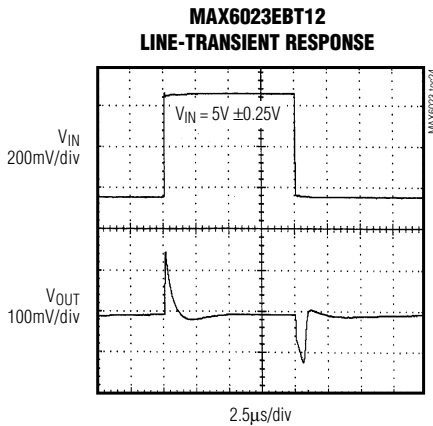
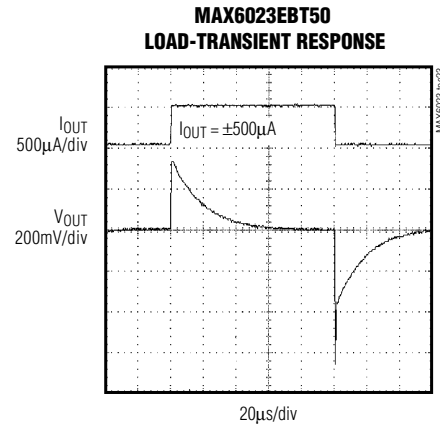
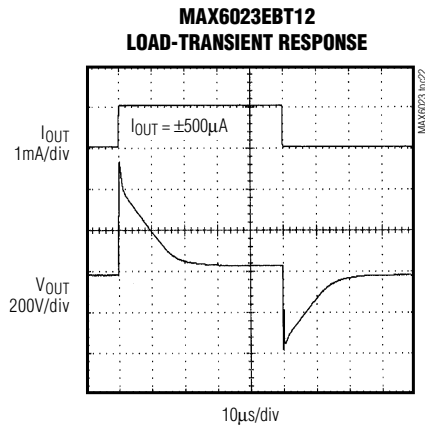
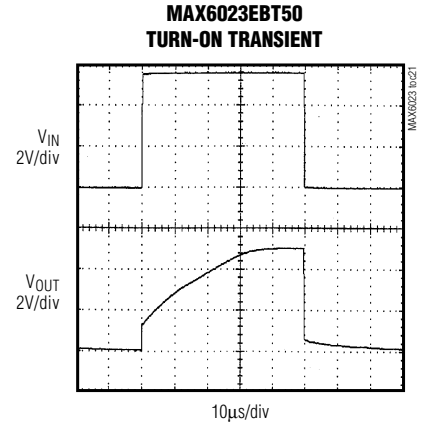
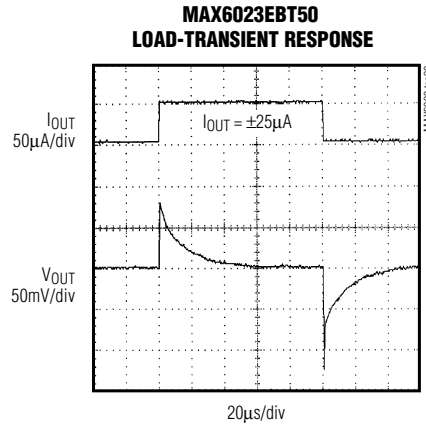
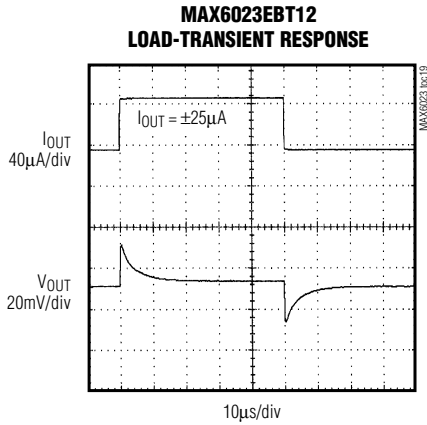


Precision, Low-Power, Low-Dropout, UCSP Voltage Reference

MAX6023

Typical Operating Characteristics (continued)

($V_{IN} = +5V$ for MAX6023EBT12/21/25/30/41/45, $V_{IN} = +5.5V$ for MAX6023EBT50; $I_{OUT} = 0$; $T_A = +25^\circ C$, unless otherwise noted.) (Note 6)



Note 6: Many of the *Typical Operating Characteristics* of the MAX6023 family are extremely similar. The extremes of these characteristics are found in MAX6023EBT12 (1.25V output) and the MAX6023EBT50 (5.0V output). The *Typical Operating Characteristics* of the remainder of the MAX6023 family typically lie between these two extremes and can be estimated based on their output voltage.

Precision, Low-Power, Low-Dropout, UCSP Voltage Reference

Pin Description

| BUMP | NAME | FUNCTION |
|--------|------|---|
| A1, A3 | I.C. | Internally connected. Do not connect to this pin. |
| A2 | GND | Ground |
| B1 | OUT | Reference Output |
| B3 | IN | Input Voltage |

Detailed Description

The MAX6023 precision bandgap references use a proprietary curvature correction circuit and laser-trimmed thin-film resistor, resulting in a low temperature coefficient of <math><30\text{ppm}/^\circ\text{C}</math> and initial accuracy of better than 0.2%. These devices can sink and source up to 500 μA with <math><200\text{mV}</math> of dropout voltage, making them attractive for use in low-voltage applications.

Applications Information

Output/Load Capacitance

The MAX6023 devices do not require an output capacitor for dynamically stable, oscillation-free operation. 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 reduces the amount of overshoot (or undershoot) and improves the circuit's transient response. Many applications do not need an external capacitor and this family offers a significant advantage in these applications when board space is critical.

Supply Current

The no-load supply current of these series-mode references is 35 μA maximum, and is virtually independent of the supply voltage, with only a 0.8 $\mu\text{A}/\text{V}$ variation from the supply voltage. Unlike shunt-mode references that must draw the maximum load current at all times, the load current is drawn from the input voltage source 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 200 μA 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 $T_A = +25^\circ\text{C}$ 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 90ppm.

Turn-On Time

These devices typically turn on and settle within 0.1% of their final value; 30 μs to 220 μs 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.

UCSP Information

UCSP Package Consideration

For general UCSP package information and PC layout considerations, refer to the Maxim Application Note: UCSP—A Wafer-Level Chip-Scale Package.

UCSP Reliability

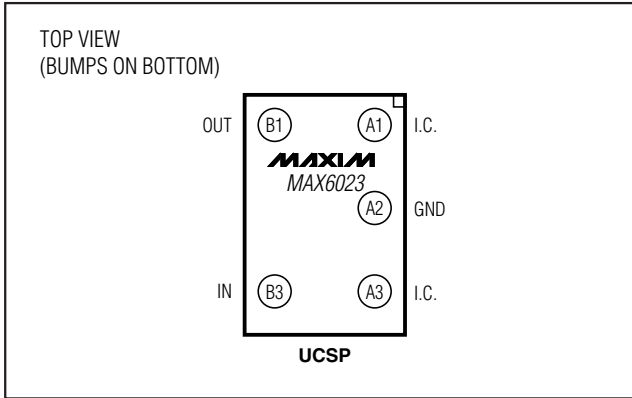
The UCSP represents a unique package that greatly reduces board space compared to other packages. The chip-scale package represents a unique packaging form factor that may not perform as well as a packaged product through traditional mechanical reliability tests. UCSP reliability is integrally linked to the user's assembly methods, circuit board material, and usage environment. The user should closely review these areas when considering use of a chip-scale package.

Performance through operating-life test and moisture resistance remains uncompromised. The wafer-fabrication process primarily determines the performance. Mechanical stress performance is a greater consideration for chip-scale packages. Chip-scale packages are attached through direct solder contact to the user's PC board, foregoing the inherent stress relief of a packaged product lead frame. Solder joint contact integrity must be considered. Comprehensive reliability tests have been performed and are available upon request. In conclusion, the UCSP performs reliably through environmental stresses.

Precision, Low-Power, Low-Dropout, UCSP Voltage Reference

MAX6023

Pin Configuration



Chip Information

TRANSISTOR COUNT: 70

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.

TOP VIEW

| COMMON DIMENSIONS | | VARIABLE DIMENSIONS | | DEPOPULATED SOLDER BALLS | |
|-------------------|-------------|---------------------|-----------|--------------------------|------|
| | | D | E | | |
| A | 0.60±0.05 | B6-1 | 1.00±0.05 | 1.52±0.05 | NONE |
| A1 | 0.27±0.03 | B6-2 | 1.00±0.05 | 1.52±0.05 | B2 |
| A2 | 0.33 REF. | B6-3 | 1.05±0.05 | 1.57±0.05 | NONE |
| b | ∅0.37 BASIC | B6-4 | 1.05±0.05 | 1.57±0.05 | B2 |
| D1 | 0.50 BASIC | B6-5 | 0.97±0.05 | 1.46±0.05 | NONE |
| E1 | 1.00 BASIC | B6-6 | 1.16±0.05 | 1.57±0.05 | NONE |
| e | 0.50 BASIC | | | | |
| SD | 0.25 BASIC | | | | |
| SE | 0.00 BASIC | | | | |

NOTES:
 1. ALL DIMENSIONS ARE IN MILLIMETERS.
 2. PRODUCT MARKING: NUMBER OF CHARACTERS AND LINES VARY PER PRODUCT.

BOTTOM VIEW

SIDE VIEW

MAXIM

PROPRIETARY INFORMATION

TITLE:
PACKAGE OUTLINE, 3x2 UCSP

| | | |
|----------|---------------------------------|------------|
| APPROVAL | DOCUMENT CONTROL NO. 21-0097 | REV. F 1/1 |
|----------|---------------------------------|------------|

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Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 408-737-7600 13