19-2182; Rev 2; 12/02

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



## 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 ±0.2% and 30ppm/°C temperature drift over the -40°C to +85°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 27µA of supply current. And unlike shunt-mode (two-terminal) references, the supply current of the MAX6023 family varies only 0.8µA/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 | ($V_{OUT}$ + 200mV) to 12.6 |
| MAX6023EBT30 | 3.000 | ($V_{OUT}$ + 200mV) to 12.6 |
| MAX6023EBT41 | 4.096 | ($V_{OUT}$ + 200mV) to 12.6 |
| MAX6023EBT45 | 4.500 | ($V_{OUT}$ + 200mV) to 12.6 |
| MAX6023EBT50 | 5.000 | ($V_{OUT}$ + 200mV) to 12.6 |



## Features

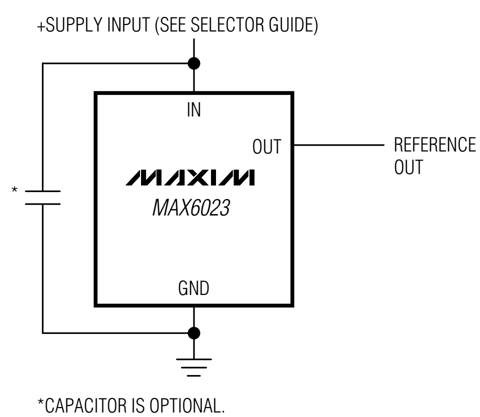
- **5-Bump UCSP Package (1.0mm × 1.5mm × 0.3mm)**
- **No Output Capacitor Needed**
- **±0.2% (max) Initial Accuracy**
- **30ppm/°C (max) Temperature Coefficient**
- **35µA (max) Quiescent Supply Current**
- **0.8µA/V (max) Supply Current Variation with $V_{IN}$**
- **100mV Dropout at 500µA Load Current**
- **Line Regulation: 160µV/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°C | 5 UCSP*-5 | AAO |
| MAX6023EBT21-T | -40°C to +85°C | 5 UCSP-5 | AAT |
| MAX6023EBT25-T | -40°C to +85°C | 5 UCSP-5 | AAP |
| MAX6023EBT30-T | -40°C to +85°C | 5 UCSP-5 | AAS |
| MAX6023EBT41-T | -40°C to +85°C | 5 UCSP-5 | AAQ |
| MAX6023EBT45-T | -40°C to +85°C | 5 UCSP-5 | AAR |
| MAX6023EBT50-T | -40°C to +85°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




*Pin Configuration appears at end of data sheet.*

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

## 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)
5-Bump UCSP (derate 3.4mW/°C above +70°C)........273mW
Operating Temperature Range ..........................-40°C to +85°C
Storage Temperature Range .............................-65°C to +150°C
Bump Temperature (soldering, 10s)................................+300°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°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **OUTPUT** | | | | | | |
| Output Voltage | $V_{OUT}$ | $T_A$ = +25°C | 1.247 | 1.250 | 1.253 | V |
| Initial Voltage Accuracy | | $T_A$ = +25°C | -0.24 | | +0.24 | % |
| Output Voltage Temperature Coefficient | | (Note 3) | | 10 | 30 | ppm/°C |
| Line Regulation | $\Delta V_{OUT}/\Delta V_{IN}$ | 2.5V ≤ $V_{IN}$ ≤ 12.6V | | 10 | 80 | µV/V |
| Load Regulation | $\Delta V_{OUT}/\Delta I_{OUT}$ | 0 ≤ $I_{OUT}$ ≤ 400µA | | 0.4 | 1.0 | µV/µA |
| | | -400µA ≤ $I_{OUT}$ ≤ 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 | $\Delta V_{OUT}$/time | 1000hr at $T_A$ = +25°C | | 30 | | ppm/1000hr |
| **DYNAMIC CHARACTERISTICS** | | | | | | |
| Noise Voltage | $e_{OUT}$ | f = 0.1Hz to 10Hz | | 25 | | µVp-p |
| | | f = 10Hz to 10kHz | | 65 | | $\mu V_{RMS}$ |
| Ripple Rejection | $\Delta V_{OUT}/\Delta I_{OUT}$ | $V_{IN}$ = +5V ±100mV, f = 120Hz | | 86 | | dB |
| Turn-On Settling Time | $t_R$ | To $V_{OUT}$ within 0.1% of final value, $C_{OUT}$ = 50pF | | 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 ≤ $V_{IN}$ ≤ 12.6V | | 0.8 | 2.0 | µA/V |

## 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 | $\Delta V_{OUT}/\Delta V_{IN}$ | 2.5V ≤ $V_{IN}$ ≤ 12.6V | | 20 | 100 | µV/V |
| Load Regulation | $\Delta V_{OUT}/\Delta I_{OUT}$ | 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 | $\Delta V_{OUT}$/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 | $\Delta V_{OUT}/\Delta I_{OUT}$ | $V_{IN}$ = +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 |

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

## 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°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **OUTPUT** | | | | | | |
| Output Voltage | $V_{OUT}$ | $T_A$ = +25°C | 2.495 | 2.5 | 2.505 | V |
| Initial Voltage Accuracy | | $T_A$ = +25°C | -0.20 | | +0.20 | % |
| Output Voltage Temperature Coefficient | | (Note 3) | | 10 | 30 | ppm/°C |
| Line Regulation | $\Delta V_{OUT}/\Delta V_{IN}$ | ($V_{OUT}$ + 0.2V) ≤ $V_{IN}$ ≤ 12.6V | | 25 | 140 | µV/V |
| Load Regulation | $\Delta V_{OUT}/\Delta I_{OUT}$ | 0 ≤ $I_{OUT}$ ≤ 500µA | | 0.5 | 1.4 | µV/µA |
| | | -500µA ≤ $I_{OUT}$ ≤ 0 | | 0.3 | 0.8 | |
| Short-Circuit Current | $I_{SC}$ | Short to GND | | 4 | | mA |
| | | Short to IN | | 10 | | |
| Dropout Voltage | ($V_{IN}$ - $V_{OUT}$) | $I_{OUT}$ = 500µA (Note 5) | | 100 | 200 | mV |
| Temperature Hysteresis | | (Note 4) | | 90 | | ppm |
| Long-Term Stability | $\Delta V_{OUT}$/time | 1000hr at $T_A$ = +25°C | | 50 | | ppm/1000hr |
| **DYNAMIC CHARACTERISTICS** | | | | | | |
| Noise Voltage | $e_{OUT}$ | f = 0.1Hz to 10Hz | | 60 | | µVp-p |
| | | f = 10Hz to 10kHz | | 125 | | $µV_{RMS}$ |
| Ripple Rejection | $\Delta V_{OUT}/\Delta I_{OUT}$ | $V_{IN}$ = +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 | $V_{OUT}$ + 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 |

## 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 | $\Delta V_{OUT}/\Delta V_{IN}$ | ($V_{OUT}$ + 0.2V) ≤ $V_{IN}$ ≤ 12.6V | | 40 | 140 | µV/V |
| Load Regulation | $\Delta V_{OUT}/\Delta I_{OUT}$ | 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 | $\Delta V_{OUT}$/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 | $\Delta V_{OUT}/\Delta V_{IN}$ | $V_{IN}$ = +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 | $\Delta I_{IN}/\Delta V_{IN}$ | ($V_{OUT}$ + 0.2V) ≤ $V_{IN}$ ≤ 12.6V | | 0.8 | 2.0 | µA/V |

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

## 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 | $\Delta V_{OUT}/\Delta V_{IN}$ | ($V_{OUT}$ + 0.2V) ≤ $V_{IN}$ ≤ 12.6V | | 50 | 160 | µV/V |
| Load Regulation | $\Delta V_{OUT}/\Delta I_{OUT}$ | 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 | $\Delta V_{OUT}$/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 | | $µV_{RMS}$ |
| Ripple Rejection | $\Delta V_{OUT}/\Delta V_{IN}$ | $V_{IN}$ = +5V ±100mV, f = 120Hz | | 77 | | dB |
| Turn-On Settling Time | $t_R$ | To $V_{OUT}$ 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 |

## 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 | $\Delta V_{OUT}/\Delta V_{IN}$ | ($V_{OUT}$ + 0.2V) ≤ $V_{IN}$ ≤ 12.6V | | 50 | 160 | µV/V |
| Load Regulation | $\Delta V_{OUT}/\Delta I_{OUT}$ | 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 | $\Delta V_{OUT}$/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 | | $µV_{RMS}$ |
| Ripple Rejection | $\Delta V_{OUT}/\Delta V_{IN}$ | $V_{IN}$ = +5V ±100mV, f = 120Hz | | 82 | | dB |
| Turn-On Settling Time | $t_R$ | To $V_{OUT}$ 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 |

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

## 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)

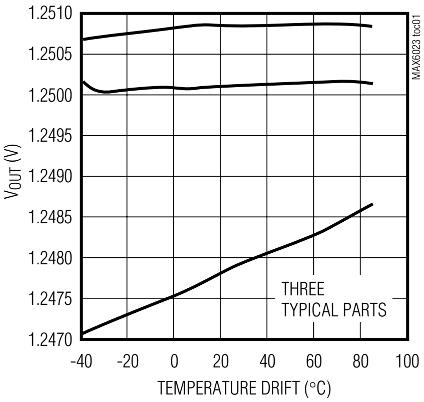
| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Output Voltage | $V_{OUT}$ | $T_A$ = +25°C | 4.990 | 5.0 | 5.010 | V |
| Initial Voltage Accuracy | | $T_A$ = +25°C | -0.20 | | +0.20 | % |
| Output Voltage Temperature Coefficient | | (Note 3) | | 10 | 30 | ppm/°C |
| Line Regulation | $\Delta V_{OUT}/\Delta V_{IN}$ | ($V_{OUT}$ + 0.2V) ≤ $V_{IN}$ ≤ 12.6V | | 50 | 160 | µV/V |
| Load Regulation | $\Delta V_{OUT}/\Delta I_{OUT}$ | 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 | $\Delta V_{OUT}$/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 | | $\mu V_{RMS}$ |
| Ripple Rejection | $\Delta V_{OUT}/\Delta V_{IN}$ | $V_{IN}$ = +5V ±100mV, f = 120Hz | | 72 | | dB |
| Turn-On Settling Time | $t_R$ | To $V_{OUT}$ 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).

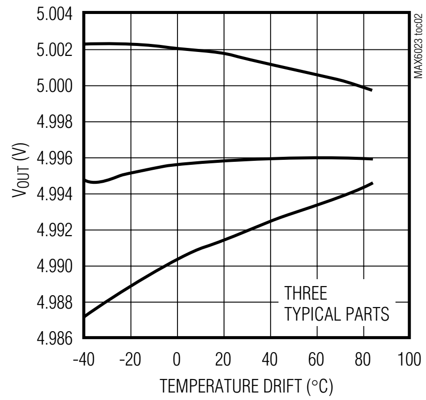
## Typical Operating Characteristics

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

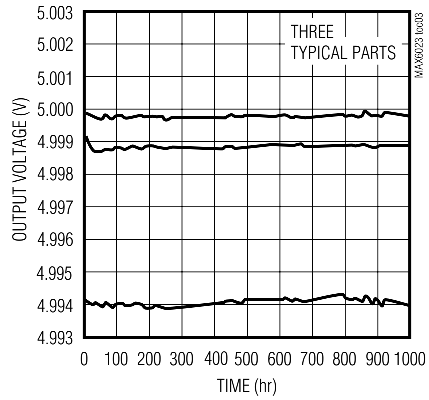
**MAX6023EBT12 OUTPUT VOLTAGE TEMPERATURE DRIFT**



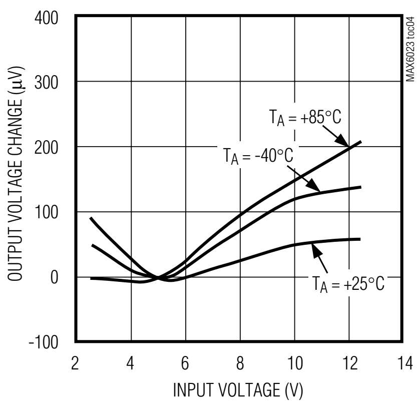

**MAX6023EBT50 OUTPUT VOLTAGE TEMPERATURE DRIFT**



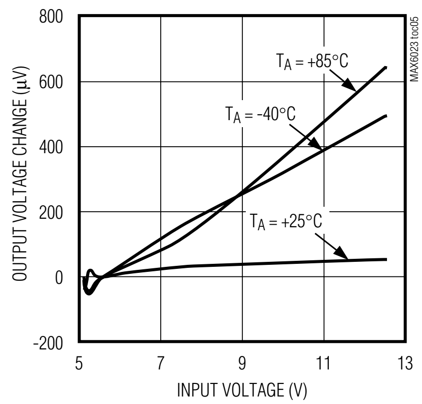

**MAX6023EBT50 LONG-TERM DRIFT**



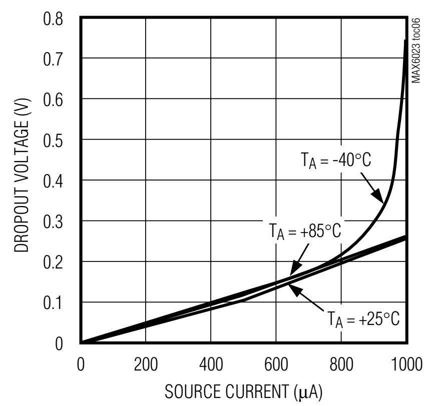

**MAX6023EBT12 LINE REGULATION**



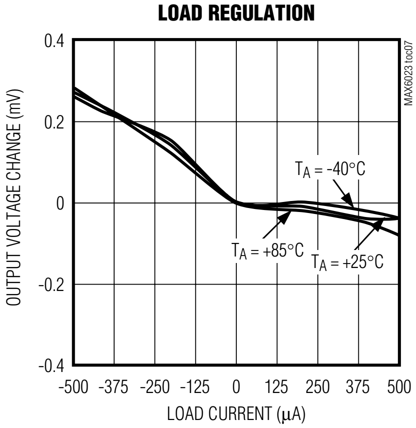

**MAX6023EBT50 LINE REGULATION**



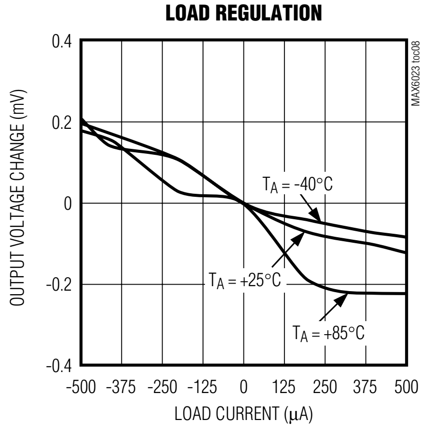

**MAX6023EBT25/30 DROPOUT VOLTAGE vs. SOURCE CURRENT**



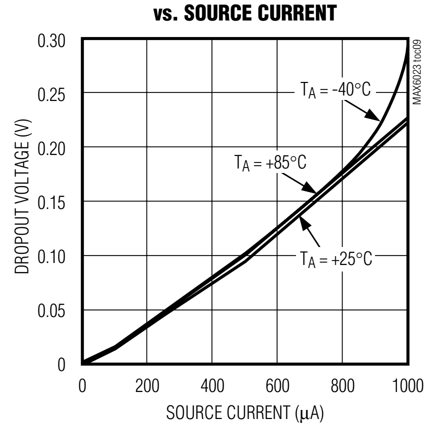

**MAX6023EBT12 LOAD REGULATION**




**MAX6023EBT50 LOAD REGULATION**




**MAX6023EBT41/45/50 DROPOUT VOLTAGE vs. SOURCE CURRENT**

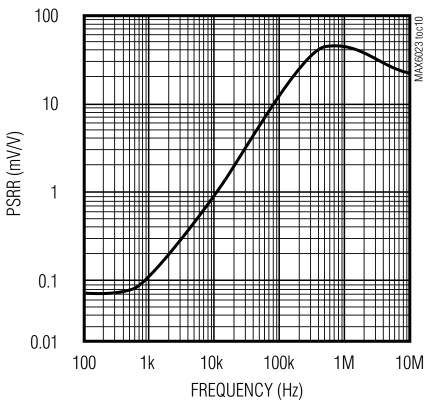


# Precision, Low-Power, Low-Dropout, UCSP Voltage Reference

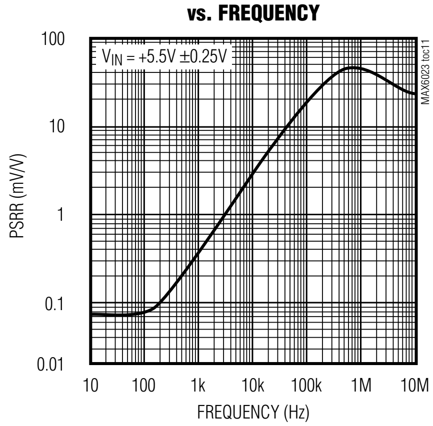
## Typical Operating Characteristics (continued)

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

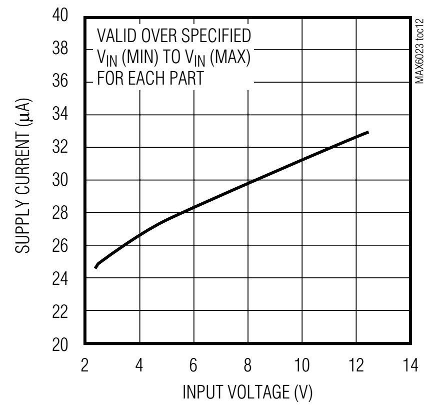
**MAX6023EBT12 POWER-SUPPLY REJECTION RATIO vs. FREQUENCY**



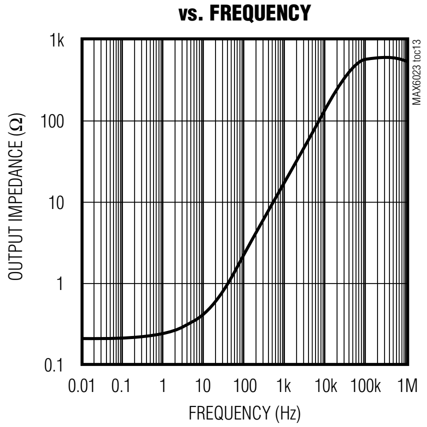

**MAX6023EBT50 POWER-SUPPLY REJECTION RATIO vs. FREQUENCY**



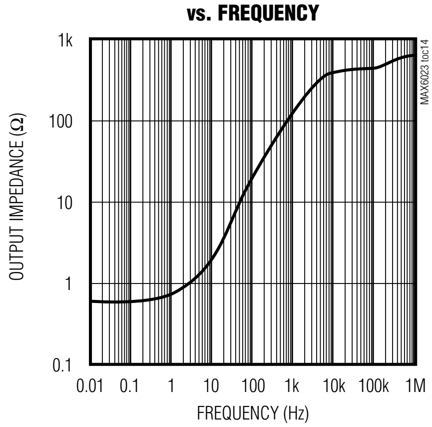

**SUPPLY CURRENT vs. INPUT VOLTAGE**



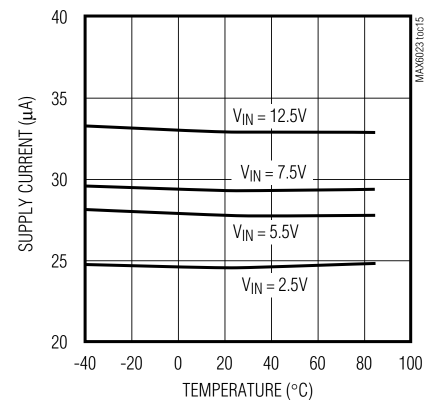

**MAX6023EBT12 OUTPUT IMPEDANCE vs. FREQUENCY**



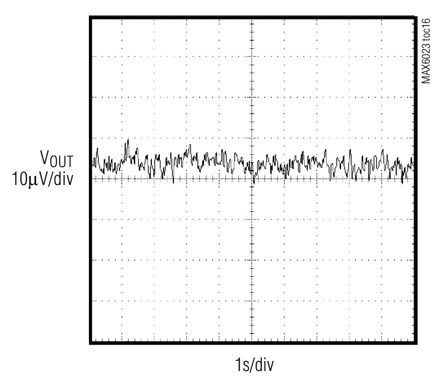

**MAX6023EBT50 OUTPUT IMPEDANCE vs. FREQUENCY**



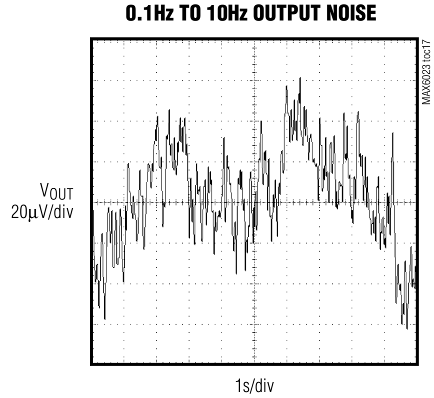

**SUPPLY CURRENT vs. TEMPERATURE**



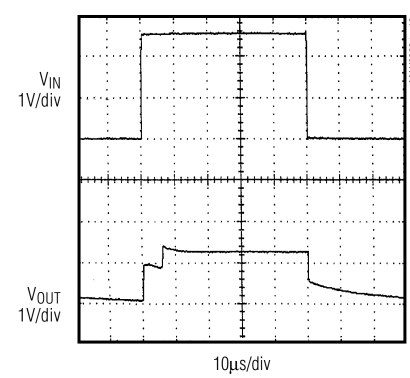

**MAX6023EBT12 0.1Hz TO 10Hz OUTPUT NOISE**




**MAX6023EBT50 0.1Hz TO 10Hz OUTPUT NOISE**



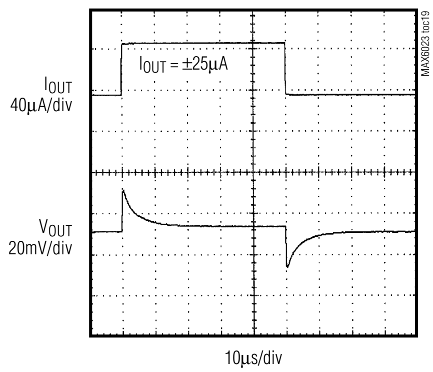

**MAX6023EBT12 TURN-ON TRANSIENT**



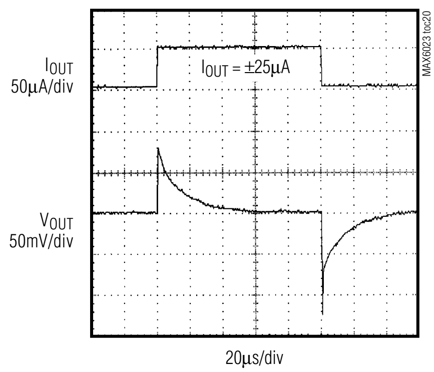
## Typical Operating Characteristics (continued)

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

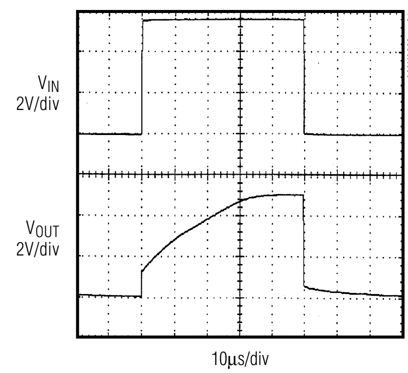
**MAX6023EBT12**
**LOAD-TRANSIENT RESPONSE**



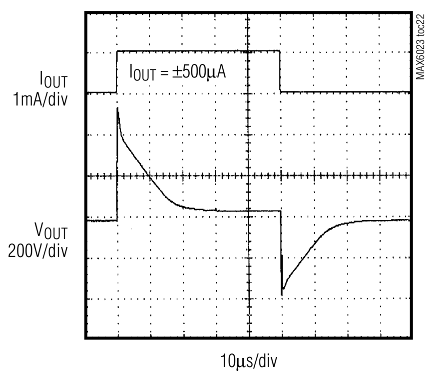

**MAX6023EBT50**
**LOAD-TRANSIENT RESPONSE**



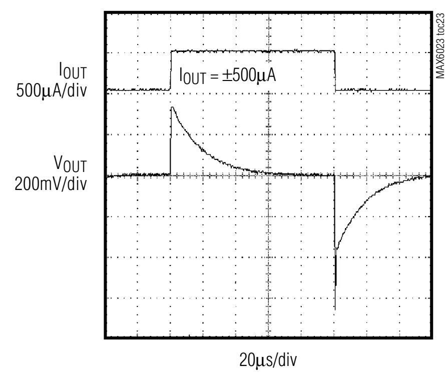

**MAX6023EBT50**
**TURN-ON TRANSIENT**



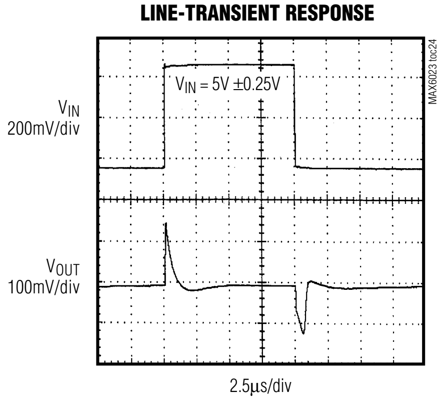

**MAX6023EBT12**
**LOAD-TRANSIENT RESPONSE**



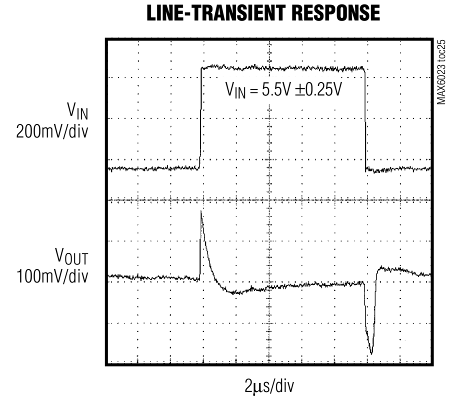

**MAX6023EBT50**
**LOAD-TRANSIENT RESPONSE**




**MAX6023EBT12**
**LINE-TRANSIENT RESPONSE**




**MAX6023EBT50**
**LINE-TRANSIENT RESPONSE**




**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 <30ppm/°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

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 35µA maximum, and is virtually independent of the supply voltage, with only a 0.8µA/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 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 90ppm.

### Turn-On Time

These devices typically turn on and settle 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.

## UCSP Information

### UCSP Package Consideration

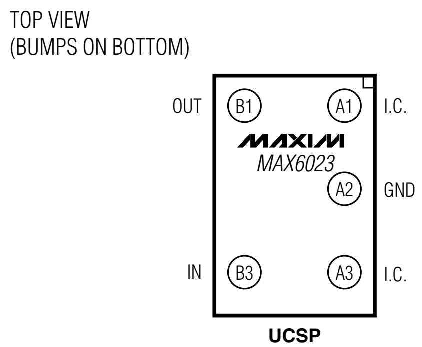
For general UCSP package information and PC layout considerations, refer to the Maxim Application Note: UCSP—A Wafer-Level Chip-Scale Package.

### 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.

## Pin Configuration



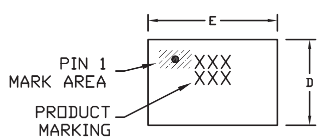

## Chip Information

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**.)

6L, UCSP.EPS

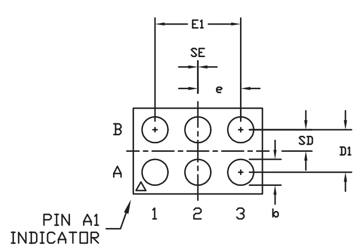



TOP VIEW

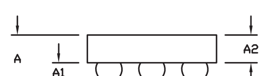
| COMMON DIMENSIONS | |
|---|---|
| A | 0.60±0.05 |
| A1 | 0.27±0.03 |
| A2 | 0.33 REF. |
| b | Ø0.37 BASIC |
| D1 | 0.50 BASIC |
| E1 | 1.00 BASIC |
| e | 0.50 BASIC |
| SD | 0.25 BASIC |
| SE | 0.00 BASIC |

| PKG. CODE | VARIABLE DIMENSIONS | | DEPOPULATED SOLDER BALLS |
|---|---|---|---|
| | D | E | |
| B6-1 | 1.00±0.05 | 1.52±0.05 | NONE |
| B6-2 | 1.00±0.05 | 1.52±0.05 | B2 |
| B6-3 | 1.05±0.05 | 1.57±0.05 | NONE |
| B6-4 | 1.05±0.05 | 1.57±0.05 | B2 |
| B6-5 | 0.97±0.05 | 1.46±0.05 | NONE |
| B6-6 | 1.16±0.05 | 1.57±0.05 | NONE |

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. | REV. | |
|---|---|---|---|
| | 21-0097 | F | 1/1 |