

### Product Overview

The REF31xx is a family of low power, low dropout, precision bandgap references. These designs are available in 3-pin SOT23 package. The REF31xx's small size and low power consumption makes them ideal for use in battery-powered systems where there can be wide variations in supply voltage and a need to minimize power dissipation. The REF31xx does not require an output compensation capacitor, yet is stable with capacitive loads and can sink or source up to  $\pm 10$  mA of output current. Unloaded, the REF31xx can operate on supplies down to 1 mV above the output voltage. All models are specified over the temperature range of  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

### Device Information

| Part Number      | Package |
|------------------|---------|
| REF3112AIDBZR-TP | SOT23   |
| REF3120AIDBZR-TP |         |
| REF3125AIDBZR-TP |         |
| REF3130AIDBZR-TP |         |
| REF3133AIDBZR-TP |         |
| REF3140AIDBZR-TP |         |

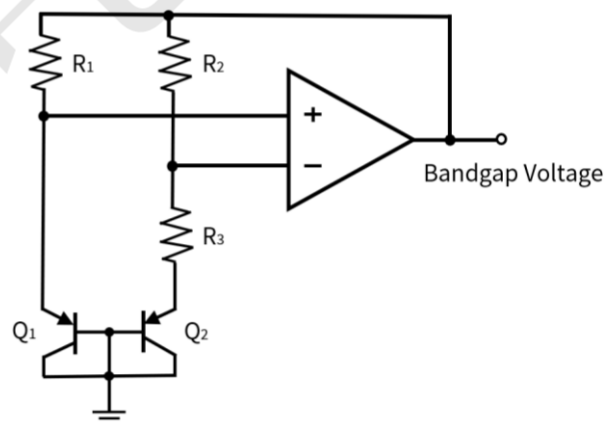
### Applications

- Data Acquisition Systems
- Medical Equipment
- Hand-Held Test Equipment

### Key Features

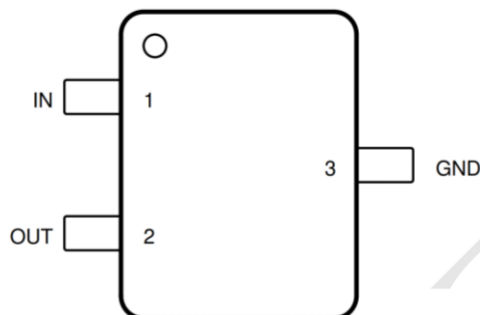
- Excellent Specified Drift Performance:  
15 ppm/ $^{\circ}\text{C}$  (Maximum) from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$
- Output Noise (0.1 to 10Hz): 22 $\mu\text{Vpp}$  of REF3133AIDBZR-TP
- High Output Current:  $\pm 10$  mA
- High Accuracy: 0.2% Maximum
- Do Not Require a Load Capacitor to Be Stable
- Low Dropout: 1mV

### Functional Block Diagram



REF31xx Functional Block Diagram

### Pin Configuration and Functions



REF31xx SOT23 Package Top View

### REF31xx Pin Configuration and Description

| PIN No. | Symbol | Function                 |
|---------|--------|--------------------------|
| 1       | IN     | Input supply voltage     |
| 2       | OUT    | Reference output voltage |
| 3       | GND    | Ground                   |

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### Absolute Maximum Ratings

| Parameters           | Symbol    | Min | Typ | Max | Unit |
|----------------------|-----------|-----|-----|-----|------|
| Input supply voltage | $V_{IN}$  |     |     | 6.5 | V    |
| Storage temperature  | $T_{stg}$ | -65 |     | 150 | °C   |
| Ambient temperature  | $T_A$     | -40 |     | 125 | °C   |
| Junction temperature | $T_J$     | -40 |     | 150 | °C   |

### ESD Ratings

| Ratings                 |                                                                 | Value | Unit |
|-------------------------|-----------------------------------------------------------------|-------|------|
| Electrostatic discharge | Human-body model (HBM), per AEC-Q100-002-RevE<br>● All pins     | ±8000 | V    |
|                         | Charged-device model (CDM), per AEC-Q100-011-RevD<br>● All pins | ±2000 | V    |

### Recommended Operating Conditions

| Parameters            | Symbol     | Min              | Typ | Max | Unit | Comments                |
|-----------------------|------------|------------------|-----|-----|------|-------------------------|
| Input voltage         | $V_{IN}$   | 1.8              |     | 5.5 | V    | REF3112AIDBZR-TP Only   |
|                       |            | $V_{OUT} + 0.05$ |     | 5.5 |      | Except REF3112AIDBZR-TP |
| Load current          | $I_{LOAD}$ | -10              |     | 10  | mA   |                         |
| Operating temperature | $T_A$      | -40              |     | 125 | °C   |                         |

### Thermal Information

| Parameters                               | Symbol              | SOT23 | Unit |
|------------------------------------------|---------------------|-------|------|
| Junction-to-ambient thermal resistance   | $\theta_{JA}$       | 298   | °C/W |
| Junction-to-case(top) thermal resistance | $\theta_{JC (top)}$ | 97    | °C/W |
| Junction-to-board thermal resistance     | $\theta_{JB}$       | 72    | °C/W |

### Electrical Characteristics

$T_A = 25^\circ\text{C}$ ,  $V_{IN} = 5\text{V}$  and  $I_{LOAD} = 0\text{mA}$  (Unless otherwise noted) <sup>1</sup>

| Parameters                       | Symbol             | Condition                                             | Min    | Typ   | Max    | Unit               |
|----------------------------------|--------------------|-------------------------------------------------------|--------|-------|--------|--------------------|
| <b>REF3112AIDBZR-TP (1.25V)</b>  |                    |                                                       |        |       |        |                    |
| Output voltage                   | $V_{OUT}$          |                                                       | 1.2475 | 1.25  | 1.2525 | V                  |
| Quiescent current                | $I_Q$              |                                                       |        | 135   | 165    | $\mu\text{A}$      |
|                                  |                    | $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$     |        |       | 170    |                    |
| Output voltage noise             | $e_{n\text{ p-p}}$ | $f = 0.1\text{Hz}$ to $10\text{Hz}$                   |        | 9     |        | $\mu\text{V}_{pp}$ |
| Line regulation                  |                    | $1.8 \leq V_{IN} \leq 5.5\text{V}$                    |        | 30    | 90     | ppm/V              |
| Turn-on settling time            |                    | to 0.1% with $C_L = 0$                                |        | 100   |        | $\mu\text{s}$      |
| <b>REF3120AIDBZR-TP (2.048V)</b> |                    |                                                       |        |       |        |                    |
| Output voltage                   | $V_{OUT}$          |                                                       | 2.044  | 2.048 | 2.052  | V                  |
| Quiescent current                | $I_Q$              |                                                       |        | 140   | 165    | $\mu\text{A}$      |
|                                  |                    | $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$     |        |       | 170    |                    |
| Output voltage noise             | $e_{n\text{ p-p}}$ | $f = 0.1\text{Hz}$ to $10\text{Hz}$                   |        | 20    |        | $\mu\text{V}_{pp}$ |
| Line regulation                  |                    | $V_{OUT} + 0.05\text{V} \leq V_{IN} \leq 5.5\text{V}$ |        | 25    | 85     | ppm/V              |
| Turn-on settling time            |                    | to 0.1% with $C_L = 0$                                |        | 250   |        | $\mu\text{s}$      |
| <b>REF3125AIDBZR-TP</b>          |                    |                                                       |        |       |        |                    |
| Output voltage                   | $V_{OUT}$          |                                                       | 2.495  | 2.5   | 2.505  | V                  |
| Quiescent current                | $I_Q$              |                                                       |        | 140   | 165    | $\mu\text{A}$      |
|                                  |                    | $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$     |        |       | 170    |                    |
| Output voltage noise             | $e_{n\text{ p-p}}$ | $f = 0.1\text{Hz}$ to $10\text{Hz}$                   |        | 22    |        | $\mu\text{V}_{pp}$ |
| Line regulation                  |                    | $V_{OUT} + 0.05\text{V} \leq V_{IN} \leq 5.5\text{V}$ |        | 15    | 85     | ppm/V              |
| Turn-on settling time            |                    | to 0.1% with $C_L = 0$                                |        | 380   |        | $\mu\text{s}$      |
| <b>REF3130AIDBZR-TP (3.0V)</b>   |                    |                                                       |        |       |        |                    |
| Output voltage                   | $V_{OUT}$          |                                                       | 2.994  | 3     | 3.006  | V                  |
| Quiescent current                | $I_Q$              |                                                       |        | 145   | 170    | $\mu\text{A}$      |
|                                  |                    | $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$     |        |       | 175    |                    |
| Output voltage noise             | $e_{n\text{ p-p}}$ | $f = 0.1\text{Hz}$ to $10\text{Hz}$                   |        | 28    |        | $\mu\text{V}_{pp}$ |
| Line regulation                  |                    | $V_{OUT} + 0.05\text{V} \leq V_{IN} \leq 5.5\text{V}$ |        | 15    | 90     | ppm/V              |
| Turn-on settling time            |                    | to 0.1% with $C_L = 0\mu\text{F}$                     |        | 450   |        | $\mu\text{s}$      |

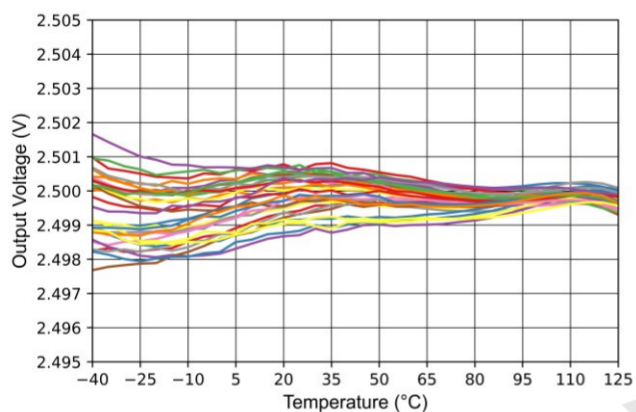
### Electrical Characteristics(continued)

$T_A = 25^\circ\text{C}$ ,  $V_{IN} = 5\text{V}$  and  $I_{LOAD} = 0\text{mA}$  (Unless otherwise noted) <sup>1</sup>

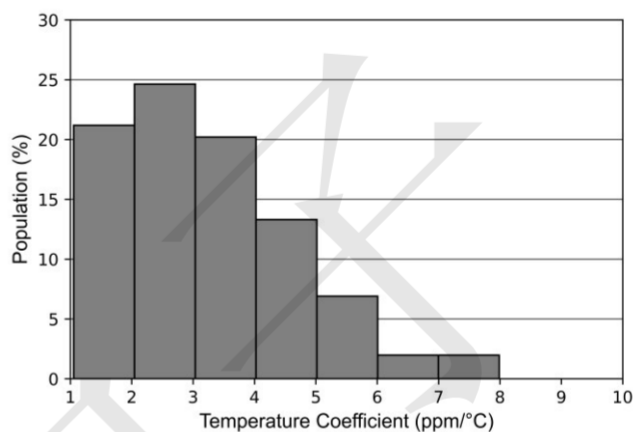
| Parameters                                                                                                                  | Symbol                    | Condition                                                                                                             | Min              | Typ   | Max   | Unit                    |
|-----------------------------------------------------------------------------------------------------------------------------|---------------------------|-----------------------------------------------------------------------------------------------------------------------|------------------|-------|-------|-------------------------|
| <b>REF3133AIDBZR-TP(3.3V)</b>                                                                                               |                           |                                                                                                                       |                  |       |       |                         |
| Output voltage                                                                                                              | $V_{OUT}$                 |                                                                                                                       | 3.294            | 3.3   | 3.306 | V                       |
| Quiescent current                                                                                                           | $I_Q$                     |                                                                                                                       |                  | 145   | 170   | $\mu\text{A}$           |
|                                                                                                                             |                           | $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$                                                                     |                  |       | 175   |                         |
| Output voltage noise                                                                                                        | $e_{n\text{ p-p}}$        | $f = 0.1\text{Hz}$ to $10\text{Hz}$                                                                                   |                  | 31    |       | $\mu\text{V}_{pp}$      |
| Line regulation                                                                                                             |                           | $V_{OUT} + 0.05\text{V} \leq V_{IN} \leq 5.5\text{V}$                                                                 |                  | 25    | 100   | ppm/V                   |
| Turn-on settling time                                                                                                       |                           | To 0.1% with $C_L = 0$                                                                                                |                  | 550   |       | $\mu\text{s}$           |
| <b>REF3140AIDBZR-TP(4.096V)</b>                                                                                             |                           |                                                                                                                       |                  |       |       |                         |
| Output voltage                                                                                                              | $V_{OUT}$                 |                                                                                                                       | 4.088            | 4.096 | 4.104 | V                       |
| Quiescent current                                                                                                           | $I_Q$                     |                                                                                                                       |                  | 145   | 175   | $\mu\text{A}$           |
|                                                                                                                             |                           | $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$                                                                     |                  |       | 175   |                         |
| Output voltage noise                                                                                                        | $e_{n\text{ p-p}}$        | $f = 0.1\text{Hz}$ to $10\text{Hz}$                                                                                   |                  | 33    |       | $\mu\text{V}_{pp}$      |
| Line regulation                                                                                                             |                           | $V_{OUT} + 0.05\text{V} \leq V_{IN} \leq 5.5\text{V}$                                                                 |                  | 50    | 150   | ppm/V                   |
| Turn-on settling time                                                                                                       |                           | To 0.1% with $C_L = 0$                                                                                                |                  | 680   |       | $\mu\text{s}$           |
| <b>REF31xx (REF3112AIDBZR-TP, REF3120AIDBZR-TP, REF3125AIDBZR-TP, REF3130AIDBZR-TP, REF3133AIDBZR-TP, REF3140AIDBZR-TP)</b> |                           |                                                                                                                       |                  |       |       |                         |
| Input supply voltage                                                                                                        | $V_{IN}$                  | REF3112AIDBZR-TP                                                                                                      | 1.8              |       | 5.5   | V                       |
|                                                                                                                             |                           | Except REF3112AIDBZR-TP                                                                                               | $V_{OUT} + 0.05$ |       | 5.5   |                         |
| Temperature drift <sup>2</sup>                                                                                              | $d_{V_{OUT}}/dT$          | $T_A = -40^\circ\text{C}$ to $125^\circ\text{C}$                                                                      |                  | 5     | 15    | ppm/ $^\circ\text{C}$   |
| Thermal hysteresis                                                                                                          |                           | First cycle, $T_A$ cycled from $25^\circ\text{C}$ to $125^\circ\text{C}$ to $-40^\circ\text{C}$ to $25^\circ\text{C}$ |                  | 100   |       | ppm                     |
| Load regulation                                                                                                             | $\Delta V_{Q(\Delta IL)}$ | $I_L = 0\text{mA}$ to $10\text{mA}$ , $V_{IN} = V_{OUT} + 0.25\text{V}$ <sup>3</sup>                                  |                  | 5     | 10    | $\mu\text{V}/\text{mA}$ |
|                                                                                                                             |                           | $I_L = -10\text{mA}$ to $0\text{mA}$ , $V_{IN} = V_{OUT} + 0.1\text{V}$ <sup>3</sup>                                  |                  | 25    | 50    |                         |
| Output current                                                                                                              | $I_{LOAD}$                | Guaranteed by Load Regulation                                                                                         | -10              |       | +10   | mA                      |
| Dropout voltage                                                                                                             | $V_{IN} - V_{OUT}$        |                                                                                                                       |                  | 1     |       | mV                      |
| Short-circuit current                                                                                                       | $I_{SC}$                  | Sourcing                                                                                                              |                  | 40    |       | mA                      |
|                                                                                                                             |                           | Sinking                                                                                                               |                  | 55    |       |                         |
| Long-term stability                                                                                                         |                           | 0 to 1000h at $35^\circ\text{C}$                                                                                      |                  | 100   |       | ppm                     |
|                                                                                                                             |                           | 0 to 2000h at $35^\circ\text{C}$                                                                                      |                  | 130   |       | ppm                     |

### Typical Performance Characteristics

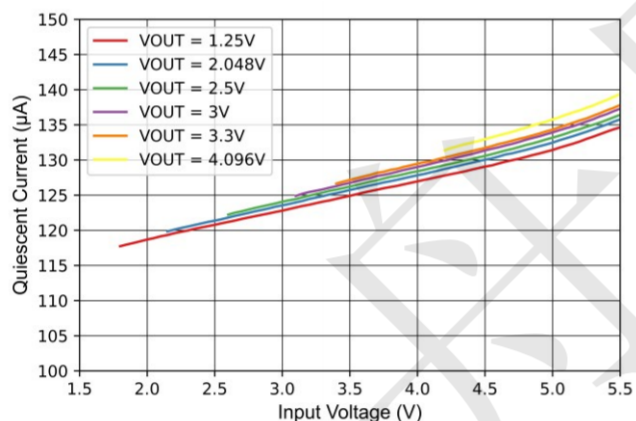
$T_A = 25^\circ\text{C}$ ,  $V_{IN} = 5\text{V}$  and  $I_{LOAD} = 0\text{mA}$  (Unless otherwise noted)



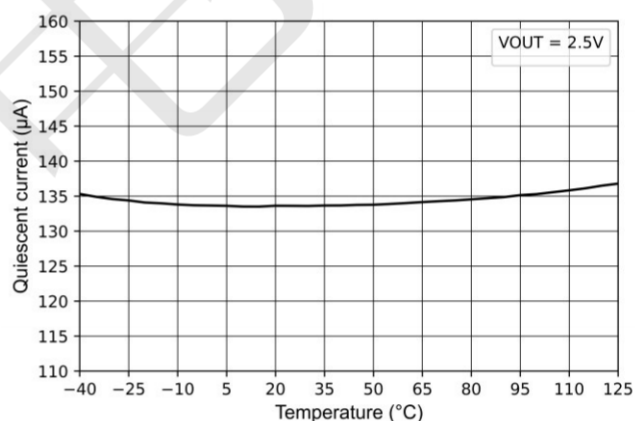
Output Voltage vs Temperature



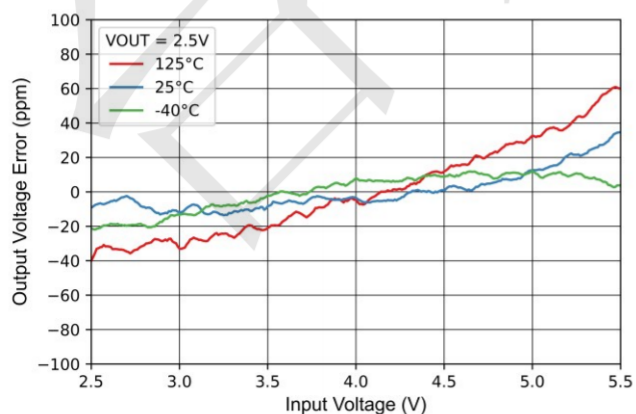
Temperature Drift Histogram



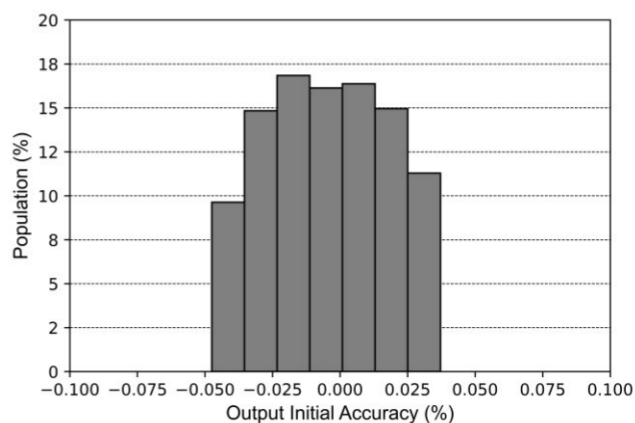
Quiescent Current vs Input Voltage



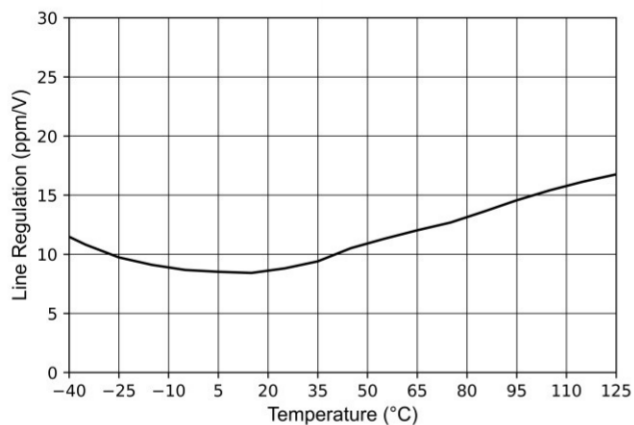
Quiescent Current vs Temperature



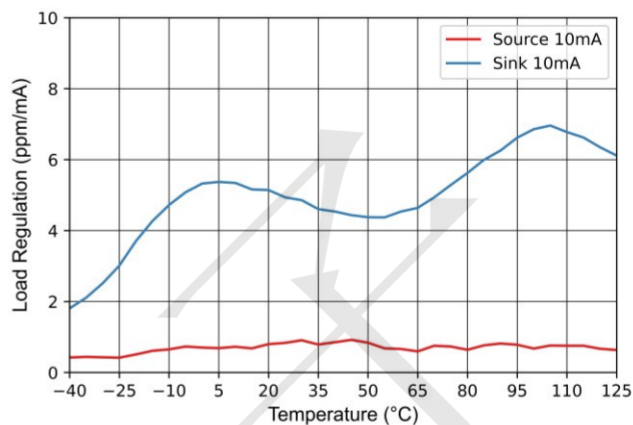
Output Voltage Error vs Input Voltage



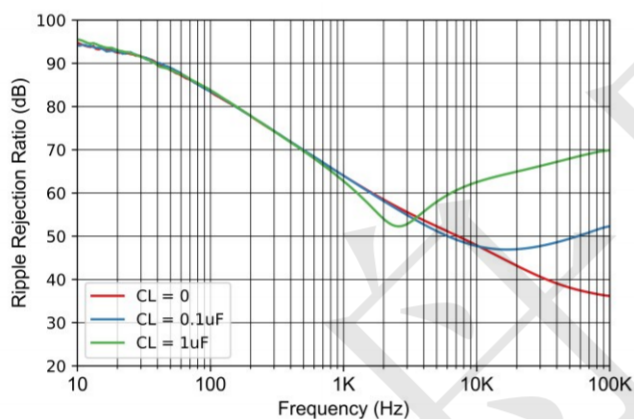
Accuracy Distribution



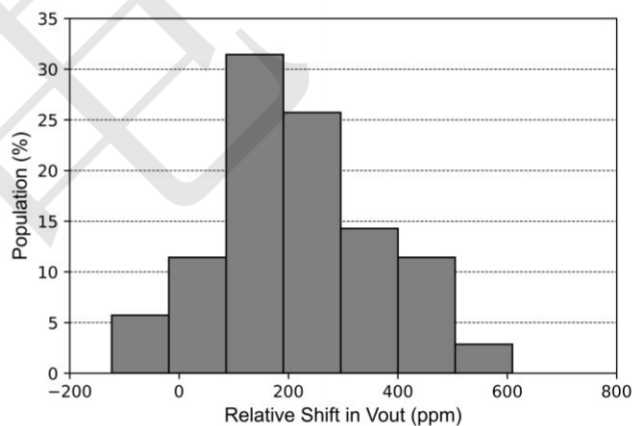
Line Regulation vs Temperature



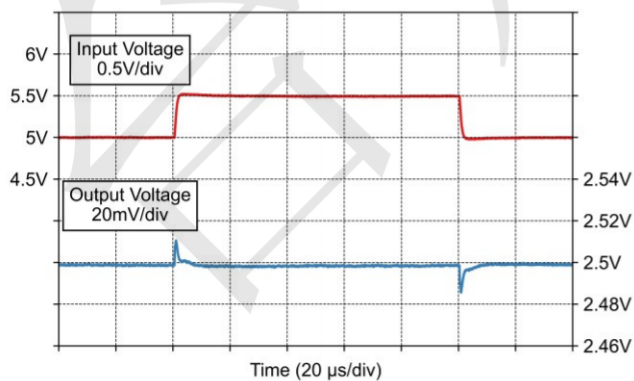
Load Regulation vs Temperature



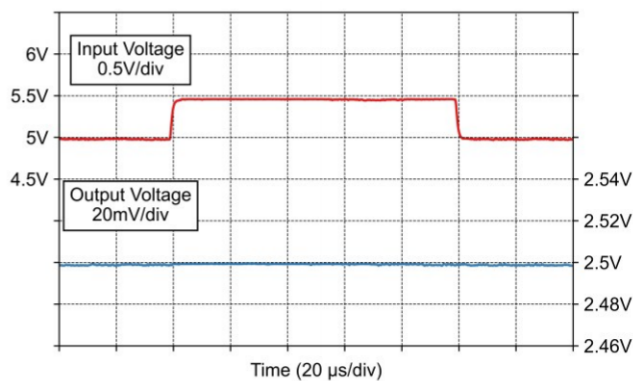
Ripple Rejection Ratio vs Frequency



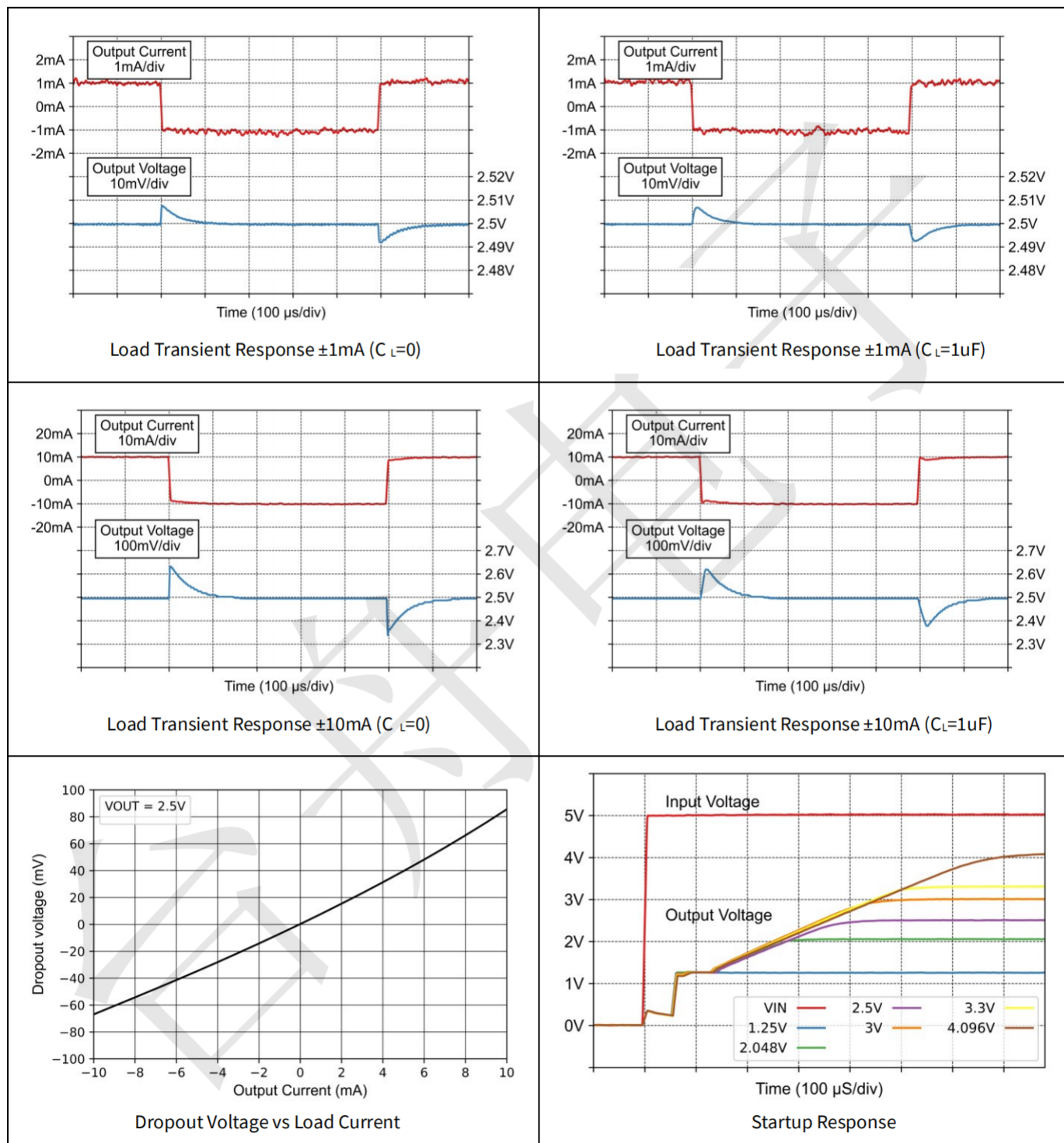
Solder Heat Reflow Shift Histogram

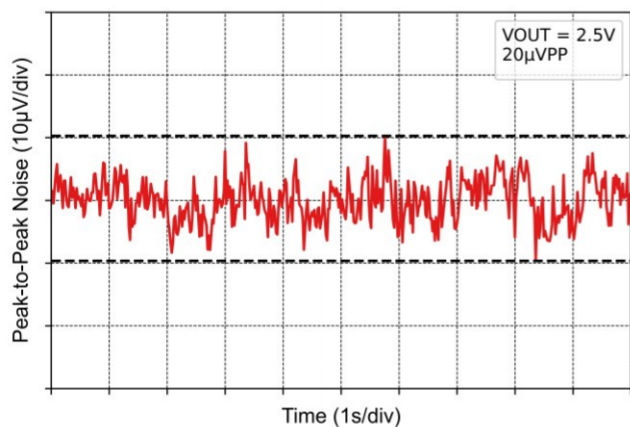


Line Transient Response ( $C_L=0$ )

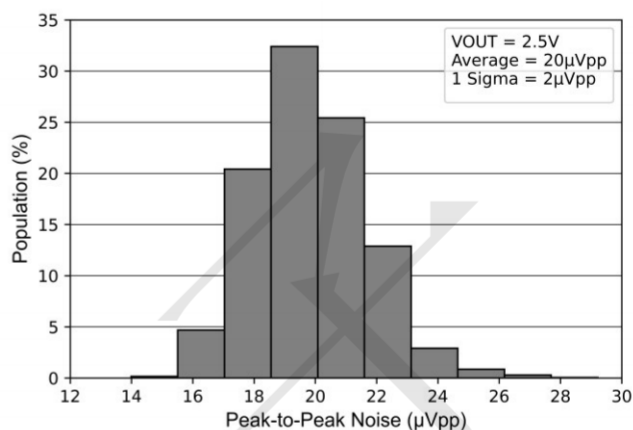


Line Transient Response ( $C_L=1\mu F$ )

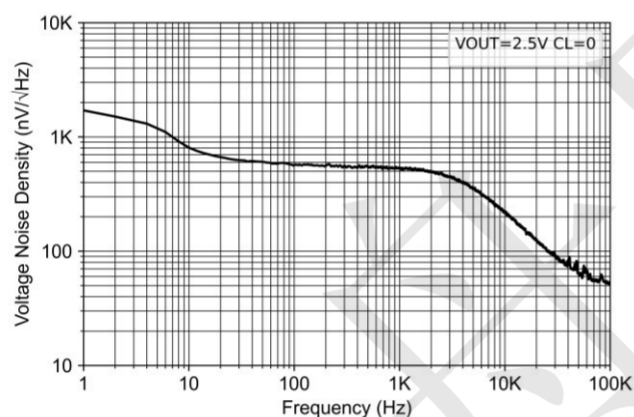




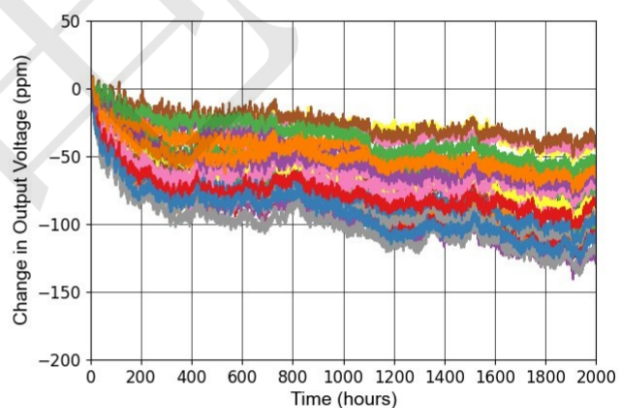
0.1Hz to 10Hz Voltage Noise



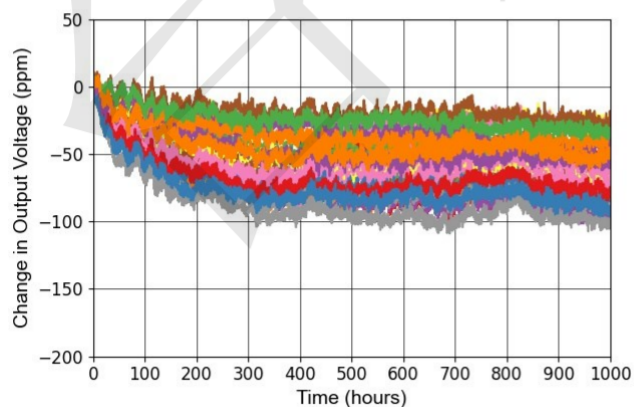
0.1Hz to 10Hz Noise Histogram



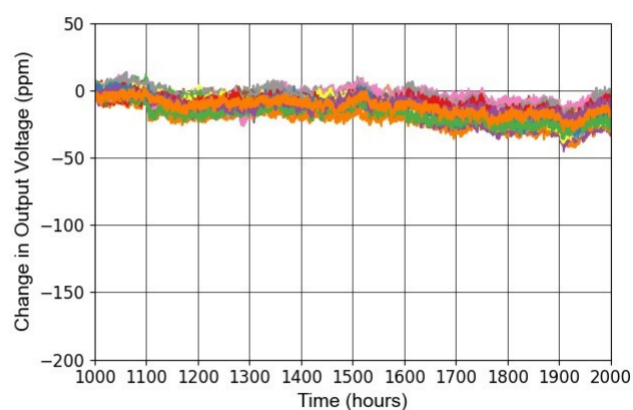
Noise Density vs Frequency



Long Term Drift 0 to 2000 hours, T<sub>A</sub>=35°C



Long Term Drift 0 to 1000 hours, T<sub>A</sub>=35°C



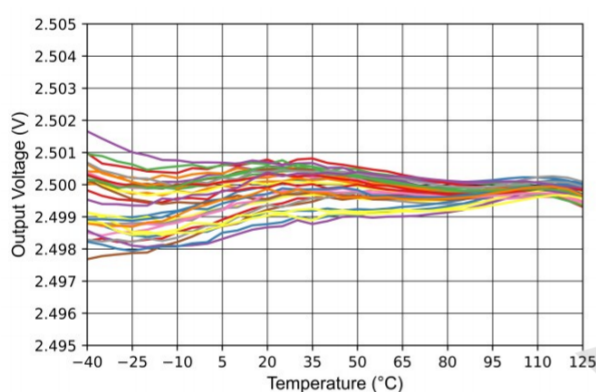
Long Term Drift 1000 to 2000 hours, T<sub>A</sub>=35°C

### Application Information

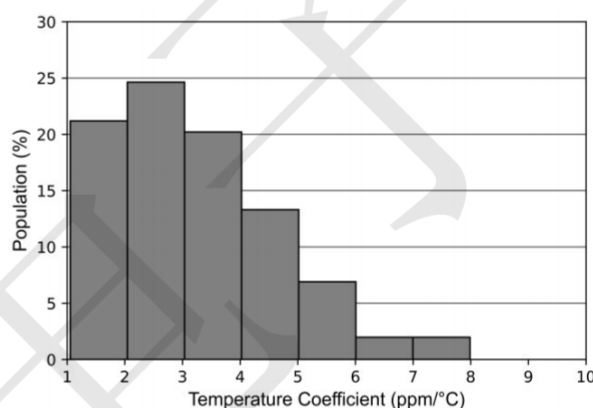
#### Temperature Coefficient

The temperature coefficient is defined as the change in output voltage over temperature. The temperature coefficient is calculated using the box method in which a box is formed by the minimum and maximum values for the nominal output voltage over the operating temperature range. REF31xx series have a low maximum temperature coefficient of 15 ppm/°C from -40°C to +125°C.

$$\text{Temperature Coefficient} = \left( \frac{V_{OUT\_MAX} - V_{OUT\_MIN}}{V_{OUT\_NOMINAL} \times \text{Temperature Range}} \right) \times 10^6$$



Output Voltage vs Temperature

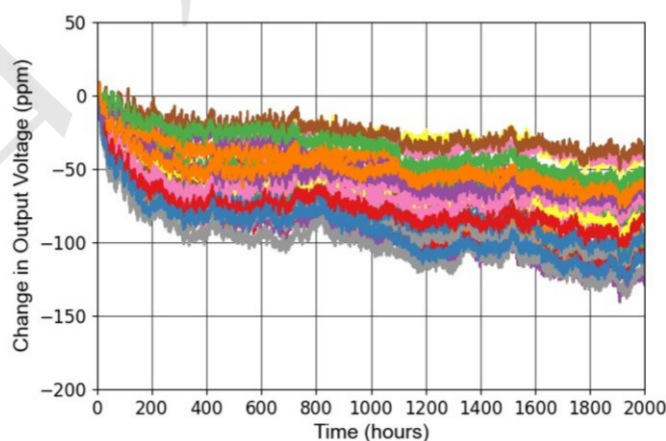


Temperature Drift Histogram

The box method specifies limits for the temperature error but does not specify the exact shape and slope of the devices under test. Due to temperature curvature correction to achieve low-temperature drift, the temperature drift is expected to be non-linear. Use for the box method.

#### Long-Term Stability

The long-term stability value is tested in a setup that reflects standard PCB board manufacturing practices. The boards are made of standard FR4 material and the board does not have special cuts or grooves around the devices to relieve the mechanical stress of the PCB. The devices and boards in this test do not undergo high temperature burn in post-soldering prior to testing. These conditions replicate real-world system performance and common manufacturing techniques. During the long-term stability testing, the devices under test are maintained at  $T_A=35^\circ\text{C}$  in an ultra-stable oil bath, their outputs were scanned regularly and measured with an 8.5 digit DVM.

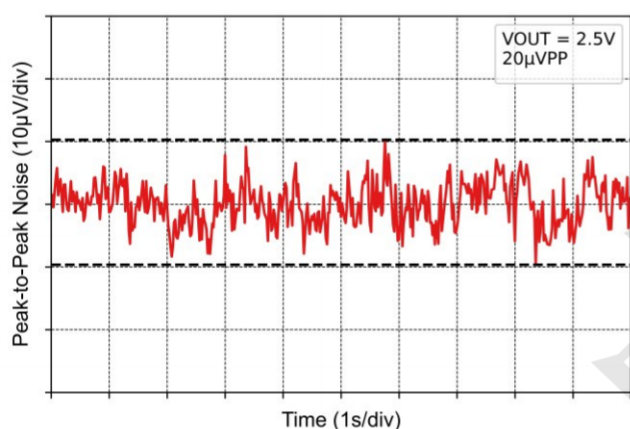


Long Term Drift 0 to 2000 hours,  $T_A=35^\circ\text{C}$

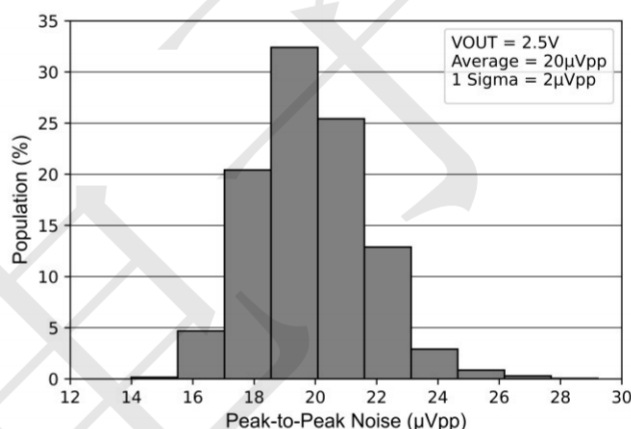
shows that the typical drift value for the REF31xx series is 130 ppm from 0 to 2000 hours. It is important to understand that long-term stability is not ensured by design and that the value is typical. The first 250 hours account most drift, Thus, the early life drift is the dominant contributor, whereas the drift after 250 hours is significantly lower.

### Noise Performance

Flicker noise, also known as 1/f noise, is a low-frequency noise that affects the device output voltage which can affect precision measurements in a data acquisition system. This noise increases proportionally with output voltage and operating temperature. REF31xx series peak-to-peak flicker noise is measured with a 2-pole high-pass filter at 0.1Hz and 2-pole low-pass filter at 10Hz, and the test time is 10 seconds. Due to the statistical nature of noise, repeating noise measurements will yield larger and smaller peak values in a given measurement interval. By repeating the measurement for 2000 intervals, each 10 seconds long, it is shown that there are time intervals during which the noise is higher than in a typical single interval, as predicted by statistical theory. For the 1000 interval test, a typical unit will exhibit noise that is less than the typical value listed in the Electrical Characteristics table in more than 80% of all units.



0.1Hz to 10Hz Voltage Noise



0.1Hz to 10Hz Noise Histogram

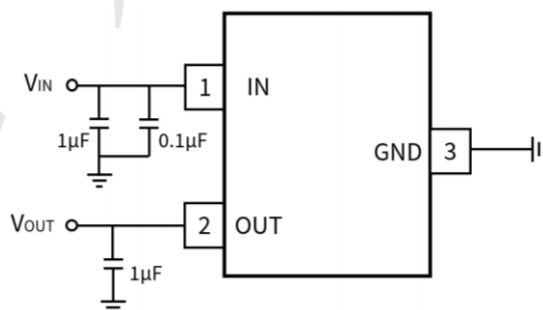
### Typical Voltage Reference Connection

#### Input Capacitors

The REF31xx series require a 1 $\mu$ F or larger input capacitor located close to IN pin to improve transient response in applications where the supply voltage may fluctuate. Connect an additional 0.1 $\mu$ F capacitor in parallel to reduce high frequency supply noise.

#### Load Capacitors

The REF31xx series does not require any output capacitance for frequency stability, an additional 1 $\mu$ F to 10 $\mu$ F electrolytic or ceramic capacitor can be added to improve transient performance in response to sudden changes in load current, however, doing so increases the turn-on time of the device.



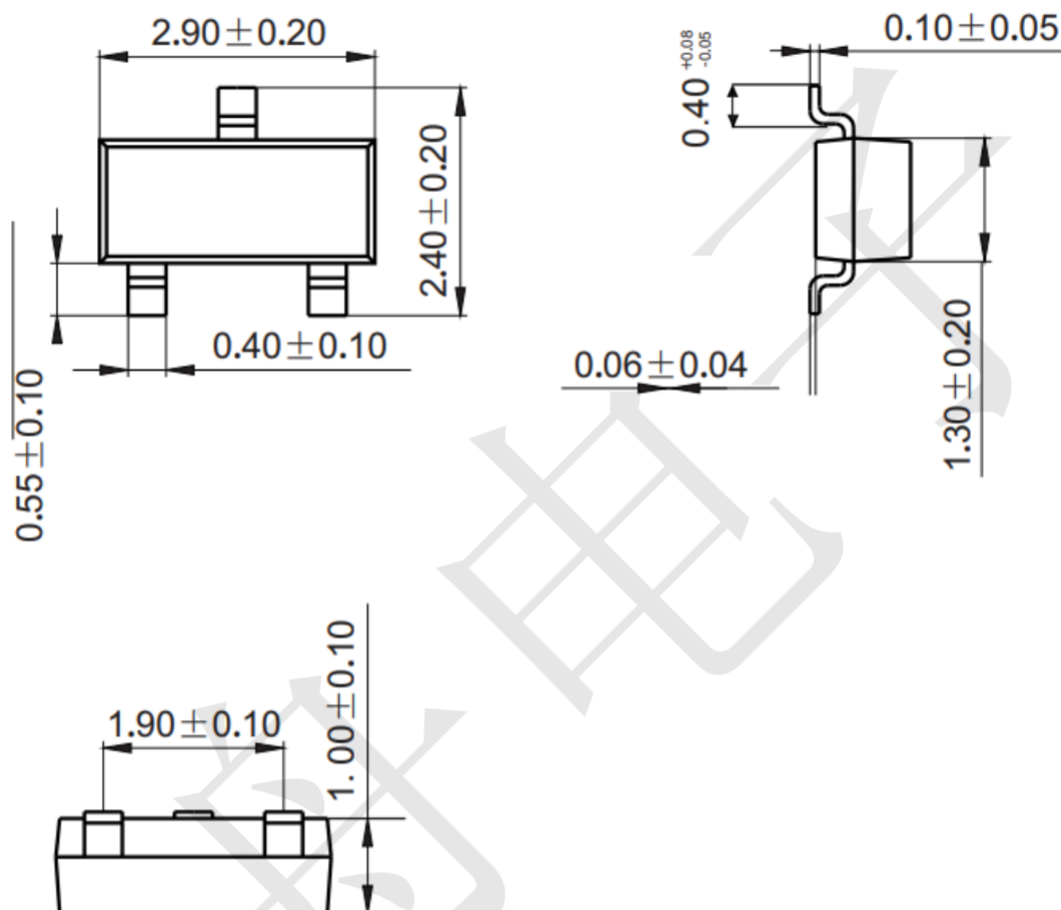
The REF31xx Typical Application Circuit

### Layout Guidelines

- Connect low-ESR, 0.1- $\mu$ F ceramic bypass capacitors at IN of the REF31xx.
- Connect low-ESR, 1- $\mu$ F to 10- $\mu$ F capacitor at OUT of the REF31xx.
- Decouple other active devices in the system per the device specifications.
- Using a solid ground plane helps distribute heat and reduces electromagnetic interference (EMI) noise pickup.
- Place the external components as close to the device as possible. This configuration prevents parasitic errors from occurring.

**Package information (Unit: mm)**

**SOT23**



**Mounting Pad Layout (Unit: mm)**

