



15ppm/°C Max, 100µA, SOT23-3 SERIES VOLTAGE REFERENCE

FEATURES

- **MicroSIZE PACKAGE:** SOT23-3
- **LOW DROPOUT:** 5mV
- **HIGH OUTPUT CURRENT:** ±10mA
- **HIGH ACCURACY:** 0.2% max
- **LOW I_Q:** 115µA max
- **EXCELLENT SPECIFIED DRIFT PERFORMANCE:**
 - 15ppm/°C (max) from 0°C to +70°C
 - 20ppm/°C (max) from -40°C to +125°C

APPLICATIONS

- PORTABLE, BATTERY-POWERED EQUIPMENT
- DATA ACQUISITION SYSTEMS
- MEDICAL EQUIPMENT
- HAND-HELD TEST EQUIPMENT

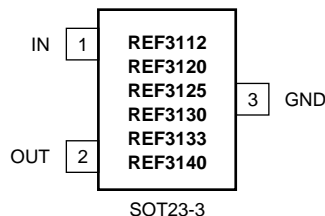
DESCRIPTION

The REF31xx is a family of precision, low power, low dropout, series voltage references available in the tiny SOT23-3 package.

The REF31xx's small size and low power consumption (100µA typ) make it ideal for portable and battery-powered applications. The REF31xx does not require a load capacitor, but is stable with any capacitive load and can sink/source up to 10mA of output current.

Unloaded, the REF31xx can be operated on supplies down to 5mV above the output voltage. All models are specified for the wide temperature range of -40°C to +125°C.

| PRODUCT | VOLTAGE (V) |
|---------|-------------|
| REF3112 | 1.25 |
| REF3120 | 2.048 |
| REF3125 | 2.5 |
| REF3130 | 3.0 |
| REF3133 | 3.3 |
| REF3140 | 4.096 |



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

| | |
|---|-----------------|
| Supply Voltage, V+ to V- | 7.0V |
| Output Short-Circuit | Continuous |
| Operating Temperature | -55°C to +135°C |
| Storage Temperature | -65°C to +150°C |
| Junction Temperature | +150°C |
| Lead Temperature (soldering, 10s) | +300°C |

NOTES: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these, or any other conditions beyond those specified, is not implied.



ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

PACKAGE/ORDERING INFORMATION⁽¹⁾

| PRODUCT | PACKAGE-LEAD | PACKAGE DESIGNATOR | SPECIFIED TEMPERATURE RANGE | PACKAGE MARKING | ORDERING NUMBER | TRANSPORT MEDIA, QUANTITY |
|---------|--------------|--------------------|-----------------------------|-----------------|-----------------|---------------------------|
| REF3112 | SOT23-3 | DBZ | -40°C to +125°C | R31A | REF3112AIDBZT | Tape and Reel, 250 |
| " | " | " | " | " | REF3112AIDBZR | Tape and Reel, 3000 |
| REF3120 | SOT23-3 | DBZ | -40°C to +125°C | R31B | REF3120AIDBZT | Tape and Reel, 250 |
| " | " | " | " | " | REF3120AIDBZR | Tape and Reel, 3000 |
| REF3125 | SOT23-3 | DBZ | -40°C to +125°C | R31C | REF3125AIDBZT | Tape and Reel, 250 |
| " | " | " | " | " | REF3125AIDBZR | Tape and Reel, 3000 |
| REF3130 | SOT23-3 | DBZ | -40°C to +125°C | R31E | REF3130AIDBZT | Tape and Reel, 250 |
| " | " | " | " | " | REF3130AIDBZR | Tape and Reel, 3000 |
| REF3133 | SOT23-3 | DBZ | -40°C to +125°C | R31F | REF3133AIDBZT | Tape and Reel, 250 |
| " | " | " | " | " | REF3133AIDBZR | Tape and Reel, 3000 |
| REF3140 | SOT23-3 | DBZ | -40°C to +125°C | R31D | REF3140AIDBZT | Tape and Reel, 250 |
| " | " | " | " | " | REF3140AIDBZR | Tape and Reel, 3000 |

NOTES: (1) For the most current package and ordering information, see the Package Option Addendum located at the end of this data sheet.

ELECTRICAL CHARACTERISTICS

Boldface limits apply over the specified temperature range, $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$.

At $T_A = +25^\circ\text{C}$, $I_{\text{LOAD}} = 0\text{mA}$, $V_{\text{IN}} = 5\text{V}$, unless otherwise noted.

| PARAMETER | CONDITIONS | REF31xx | | | UNITS |
|---|--|----------------|----------|---------------|---|
| | | MIN | TYP | MAX | |
| REF3112⁽¹⁾ - 1.25V | | | | | |
| OUTPUT VOLTAGE Initial Accuracy | V_{OUT} | 1.2475 -0.2 | 1.25 | 1.2525 0.2 | V % |
| NOISE Output Voltage Noise Voltage Noise | $f = 0.1\text{Hz to }10\text{Hz}$ $f = 10\text{Hz to }10\text{kHz}$ | | 17 24 | | μV_{PP} μV_{rms} |
| REF3120 - 2.048 | | | | | |
| OUTPUT VOLTAGE Initial Accuracy | V_{OUT} | 2.0439 -0.2 | 2.048 | 2.0521 0.2 | V % |
| NOISE Output Voltage Noise Voltage Noise | $f = 0.1\text{Hz to }10\text{Hz}$ $f = 10\text{Hz to }10\text{kHz}$ | | 27 39 | | μV_{PP} μV_{rms} |
| REF3125 - 2.5V | | | | | |
| OUTPUT VOLTAGE Initial Accuracy | V_{OUT} | 2.4950 -0.2 | 2.50 | 2.5050 0.2 | V % |
| NOISE Output Voltage Noise Voltage Noise | $f = 0.1\text{Hz to }10\text{Hz}$ $f = 10\text{Hz to }10\text{kHz}$ | | 33 48 | | μV_{PP} μV_{rms} |

ELECTRICAL CHARACTERISTICS

Boldface limits apply over the specified temperature range, $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$.

At $T_A = +25^{\circ}\text{C}$, $I_{\text{LOAD}} = 0\text{mA}$, $V_{\text{IN}} = +5\text{V}$, unless otherwise noted.

| PARAMETER | CONDITIONS | REF31xx | | | UNITS |
|--|--|---|--|---------------------------------|---|
| | | MIN | TYP | MAX | |
| REF3130 – 3.0V | | | | | |
| OUTPUT VOLTAGE Initial Accuracy | V_{OUT} | 2.9940 -0.2 | 3.0 | 3.0060 0.2 | V % |
| NOISE Output Voltage Noise Voltage Noise | $f = 0.1\text{Hz to }10\text{Hz}$ $f = 10\text{Hz to }10\text{kHz}$ | | 39 57 | | μV_{PP} μV_{RMS} |
| REF3133 – 3.3V | | | | | |
| OUTPUT VOLTAGE Initial Accuracy | V_{OUT} | 3.2934 -0.2 | 3.30 | 3.3066 0.2 | V % |
| NOISE Output Voltage Noise Voltage Noise | $f = 0.1\text{Hz to }10\text{Hz}$ $f = 10\text{Hz to }10\text{kHz}$ | | 43 63 | | μV_{PP} μV_{RMS} |
| REF3140 – 4.096V | | | | | |
| OUTPUT VOLTAGE Initial Accuracy | V_{OUT} | 4.0878 -0.2 | 4.096 | 4.1042 0.2 | V % |
| NOISE Output Voltage Noise Voltage Noise | $f = 0.1\text{Hz to }10\text{Hz}$ $f = 10\text{Hz to }10\text{kHz}$ | | 53 78 | | μV_{PP} μV_{RMS} |
| REF3112, REF3120, REF3125, REF3130, REF3133, REF3140 | | | | | |
| OUTPUT VOLTAGE TEMP DRIFT⁽²⁾ | dV_{OUT}/dT | $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$ $-40^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$ | 5 10 | 15 20 | ppm/°C ppm/°C |
| LONG-TERM STABILITY | | 0-1000h | 70 | | ppm |
| LINE REGULATION | | $V_{\text{REF}} + 0.05^{(1)} \leq V_{\text{IN}} \leq 5.5\text{V}$ | 20 | 65 | ppm/V |
| LOAD REGULATION⁽³⁾ Sourcing | $dV_{\text{OUT}}/dI_{\text{LOAD}}$ | $0\text{mA} < I_{\text{LOAD}} < 10\text{mA}$, $V_{\text{IN}} = V_{\text{REF}} + 250\text{mV}^{(1)}$ | 10 | 30 | $\mu\text{V}/\text{mA}$ |
| Sinking | | $-10\text{mA} < I_{\text{LOAD}} < 0\text{mA}$, $V_{\text{IN}} = V_{\text{REF}} + 100\text{mV}^{(1)}$ | 20 | 50 | $\mu\text{V}/\text{mA}$ |
| THERMAL HYSTERESIS⁽⁴⁾ First Cycle Additional Cycles | | dT | 100 25 | | ppm ppm |
| DROPOUT VOLTAGE⁽¹⁾ | $V_{\text{IN}} - V_{\text{OUT}}$ | | 5 | 50 | mV |
| OUTPUT CURRENT | I_{LOAD} | | -10 | 10 | mA |
| SHORT-CIRCUIT CURRENT Sourcing Sinking | I_{SC} | | 50 40 | | mA mA |
| TURN-ON SETTLING TIME | | to 0.1% at $V_{\text{IN}} = +5\text{V}$ with $C_L = 0$ | 400 | | μs |
| POWER SUPPLY Voltage Quiescent Current Over Temperature | V_S I_Q | $I_L = 0$ | $V_{\text{REF}} + 0.05^{(1)}$ 100 115 | 5.5 115 135 | V μA μA |
| TEMPERATURE RANGE Specified Range Operating Range Storage Range Thermal Resistance SOT23-3 Surface-Mount | | | -40 -55 -65 336 | +125 +135 +150 | $^{\circ}\text{C}$ $^{\circ}\text{C}$ $^{\circ}\text{C}$ $^{\circ}\text{C}/\text{W}$ |

NOTES: (1) Minimum supply voltage for REF3112 is 1.8V.

(2) Box Method used to determine temperature drift.

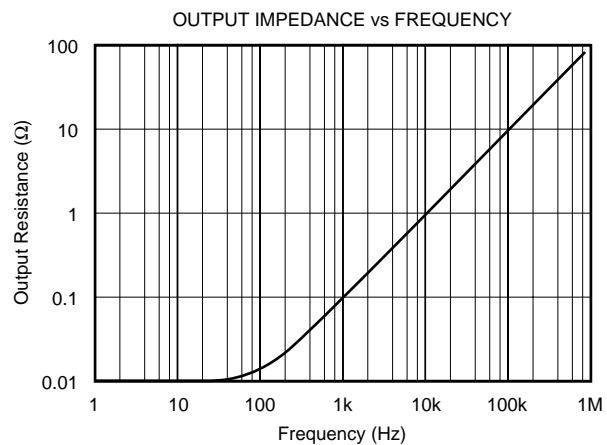
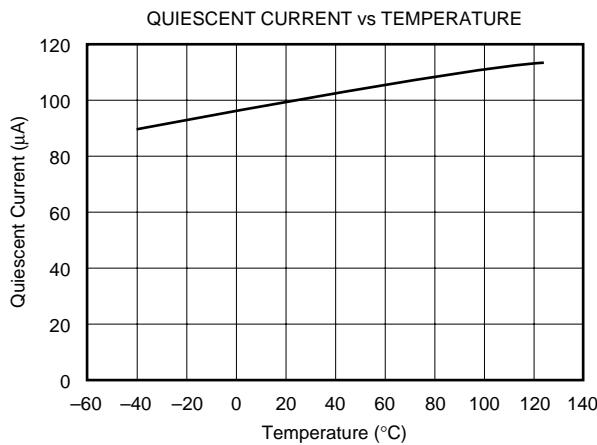
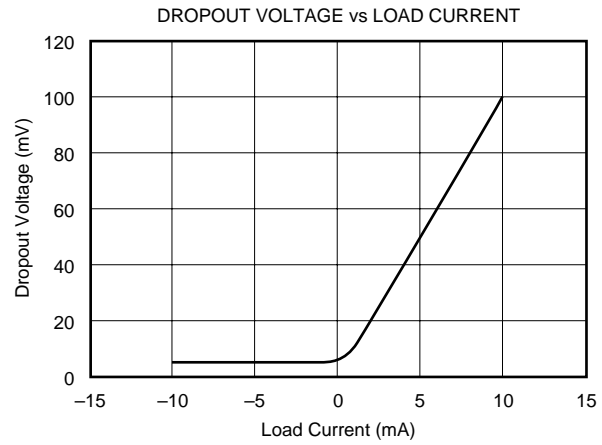
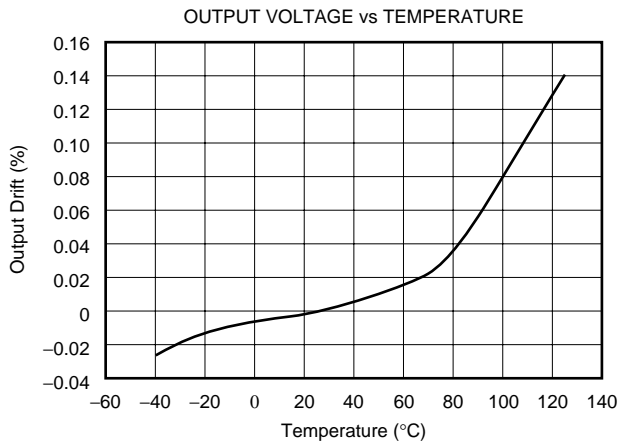
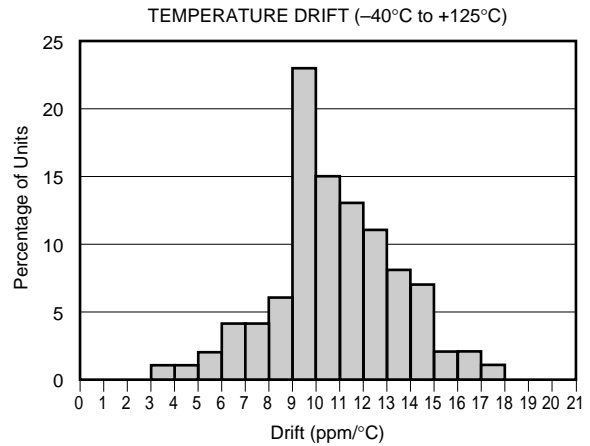
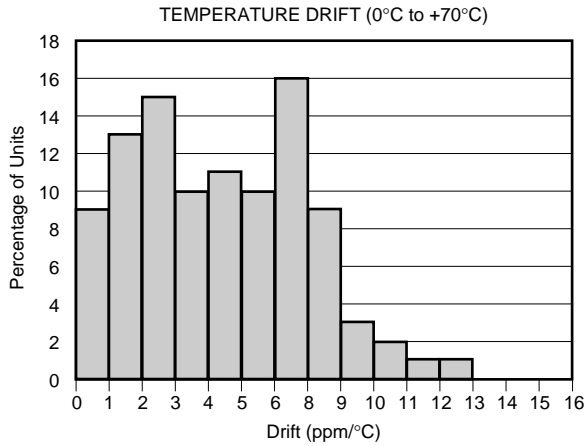
(3) Typical value of load regulation reflects measurements using force and sense contacts, see section *Load Regulation*.

(4) Thermal hysteresis is explained in more detail in Applications Information section of data sheet.

(5) For $I_L > 0$, see Typical Characteristic curves.

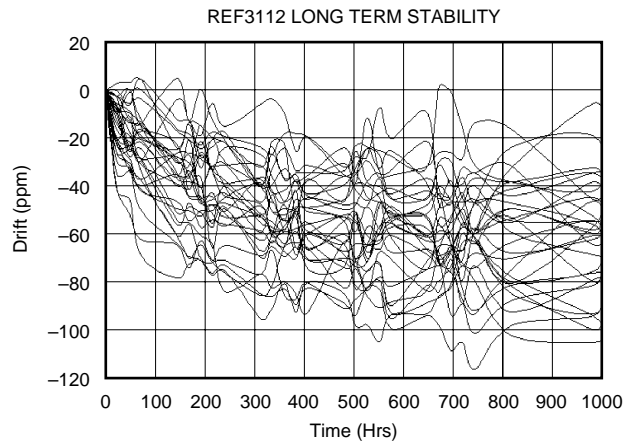
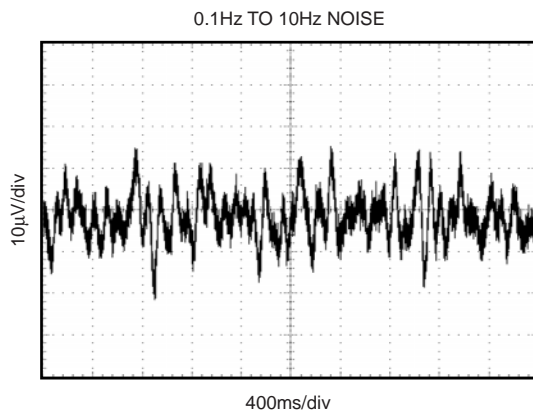
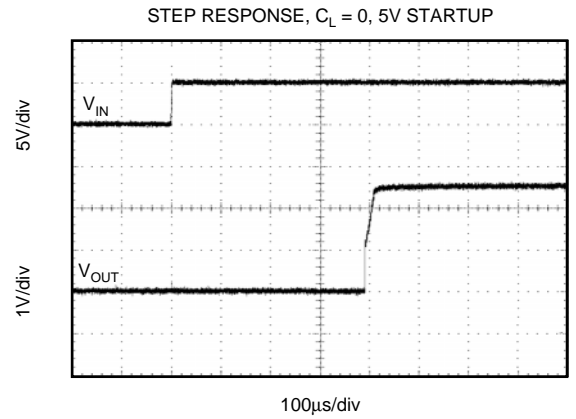
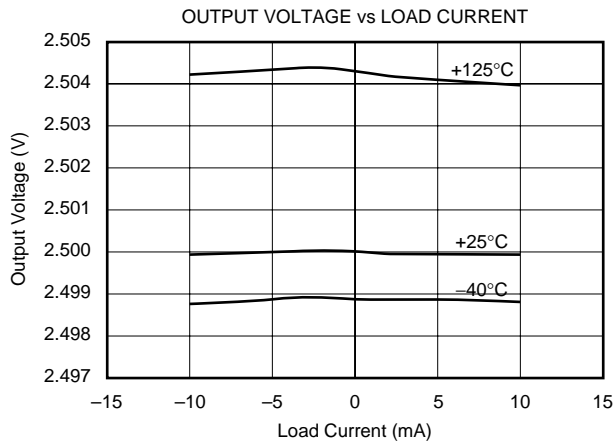
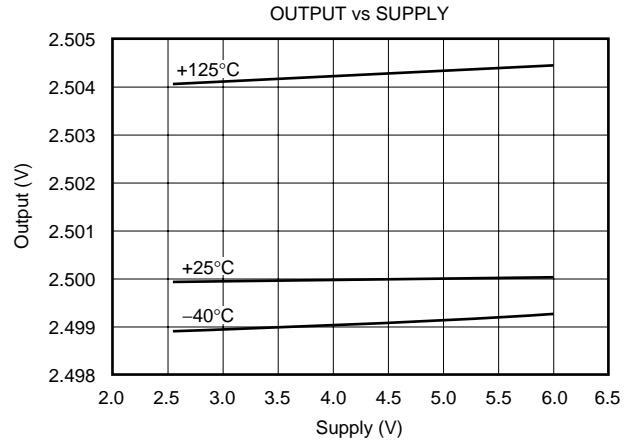
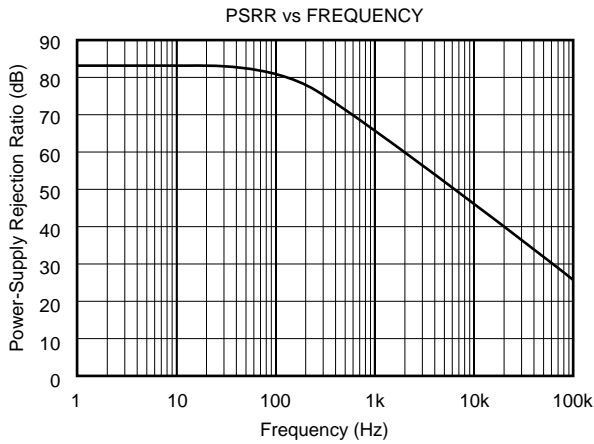
TYPICAL CHARACTERISTICS

At $T_A = +25^\circ\text{C}$, $V_{IN} = +5\text{V}$ power supply, REF3125 is used for typical characteristics, unless otherwise noted.



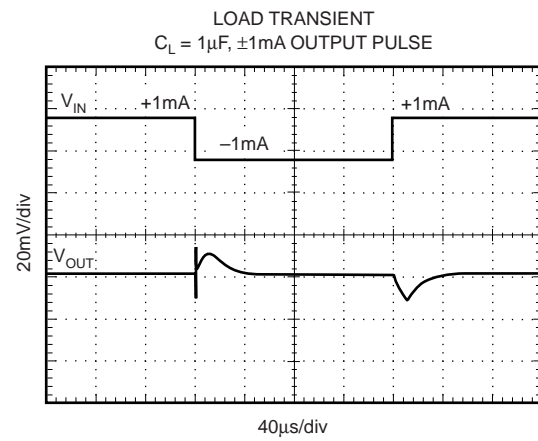
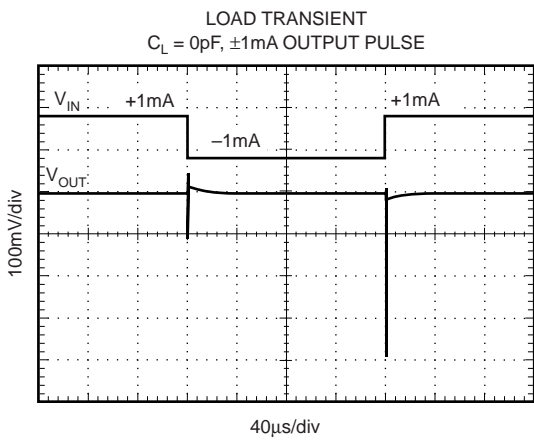
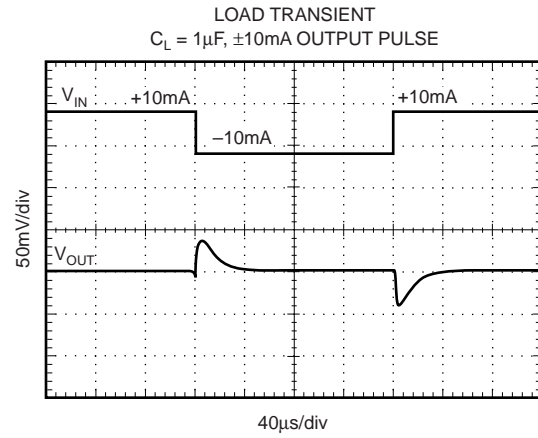
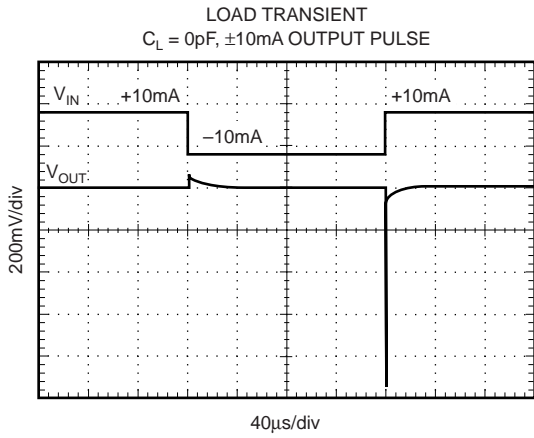
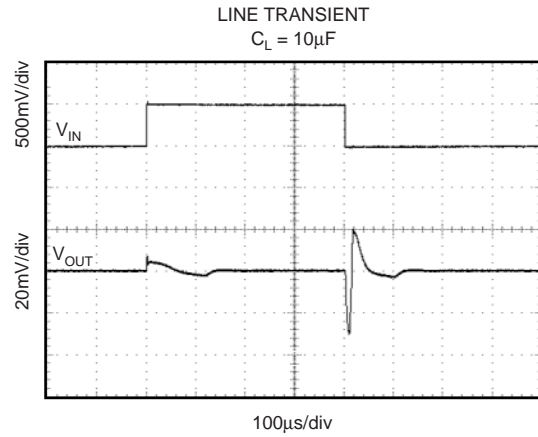
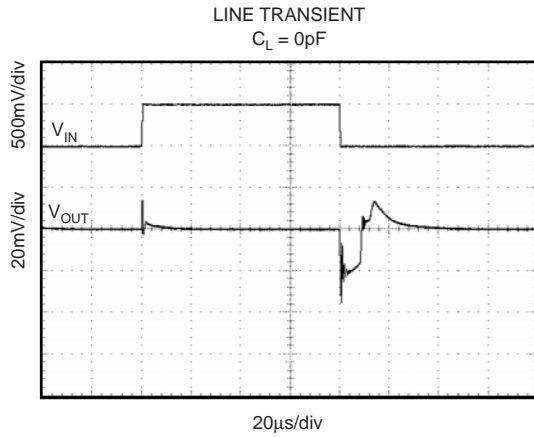
TYPICAL CHARACTERISTICS (Cont.)

At $T_A = +25^\circ\text{C}$, $V_{IN} = +5\text{V}$ power supply, REF3125 is used for typical characteristics, unless otherwise noted.



TYPICAL CHARACTERISTICS (Cont.)

At $T_A = +25^\circ\text{C}$, $V_{IN} = +5\text{V}$ power supply, REF3125 is used for typical characteristics, unless otherwise noted.



THEORY OF OPERATION

The REF31xx is a family of series, CMOS, precision bandgap voltage references. The basic bandgap topology is shown in Figure 1. Transistors Q_1 and Q_2 are biased such that the current density of Q_1 is greater than that of Q_2 . The difference of the two base-emitter voltages, $V_{be1} - V_{be2}$, has a positive temperature coefficient and is forced across resistor R_1 . This voltage is gained up and added to the base-emitter voltage of Q_2 , which has a negative temperature coefficient. The resulting output voltage is virtually independent of temperature.

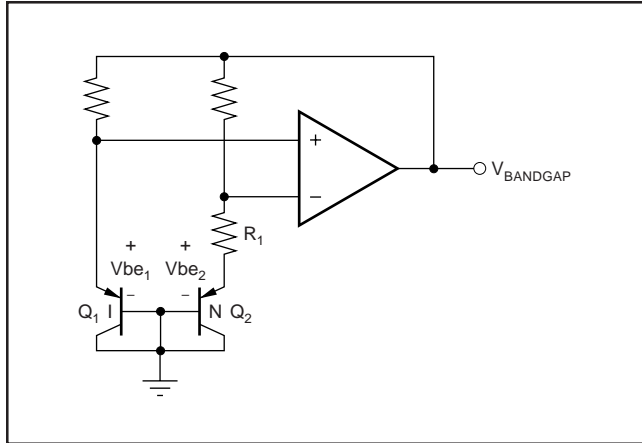


FIGURE 1. Simplified Schematic of Bandgap Reference.

APPLICATION INFORMATION

The REF31xx does not require a load capacitor and is stable with any capacitive load. Figure 2 shows typical connections required for operation of the REF31xx. A supply bypass capacitor of $0.47\mu\text{F}$ is recommended.

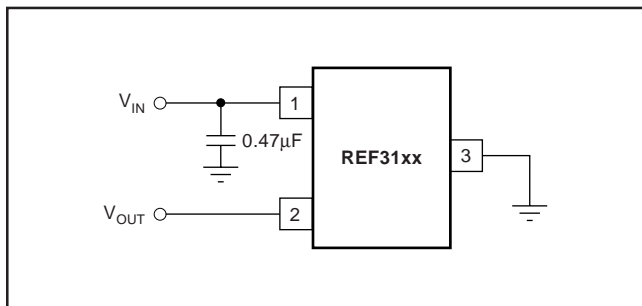


FIGURE 2. Typical Connections for Operating REF31xx.

SUPPLY VOLTAGE

The REF31xx family of references features an extremely low dropout voltage. With the exception of the REF3112, which has a minimum supply requirement of 1.8V, these references can be operated with a supply of only 5mV above the output voltage in an unloaded condition. For loaded conditions, a typical dropout voltage versus load is shown in the typical curves.

The REF31xx features a low quiescent current, which is extremely stable over changes in both temperature and supply. The typical room temperature quiescent current is

$100\mu\text{A}$, and the maximum quiescent current over temperature is just $135\mu\text{A}$. The quiescent current typically changes less than $2\mu\text{A}$ over the entire supply range, as shown in Figure 3.

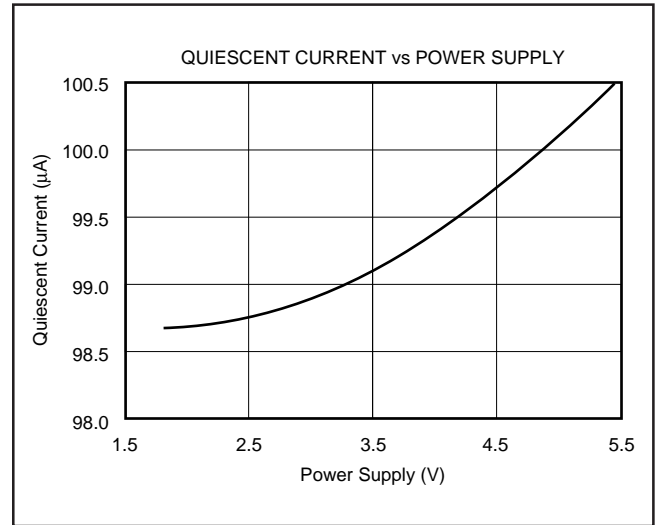


FIGURE 3. Supply Current vs Supply Voltage.

Supply voltages below the specified levels can cause the REF31xx to momentarily draw currents greater than the typical quiescent current. This can be prevented by using a power supply with a fast rising edge and low output impedance.

THERMAL HYSTERESIS

Thermal hysteresis for the REF31xx is defined as the change in output voltage after operating the device at 25°C , cycling the device through the specified temperature range, and returning to 25°C . It can be expressed as:

$$V_{\text{HYST}} = \left(\frac{\text{abs}|V_{\text{PRE}} - V_{\text{POST}}|}{V_{\text{NOM}}} \right) \cdot 10^6 (\text{ppm})$$

Where: V_{HYST} = Thermal hysteresis

V_{PRE} = Output voltage measured at 25°C pre-temperature cycling

V_{POST} = Output voltage measured after the device has been cycled through the specified temperature range of -40°C to $+125^\circ\text{C}$ and returned to 25°C .

TEMPERATURE DRIFT

The REF31xx is designed to exhibit minimal drift error, defined as the change in output voltage over varying temperature. The drift is calculated using the "box" method which is described by the following equation:

$$\left(\frac{V_{\text{OUTMAX}} - V_{\text{OUTMIN}}}{V_{\text{OUT}} \cdot \text{TemperatureRange}} \right) \cdot 10^6 \text{ppm}$$

The REF31xx features a typical drift coefficient of 5ppm from 0°C to 70°C —the primary temperature range for many applications. For the industrial temperature range of -40°C to 125°C , the REF31xx family drift increases to a typical value of 10ppm.

NOISE PERFORMANCE

Typical 0.1Hz to 10Hz voltage noise can be seen in the Typical Characteristic Curve, *0.1 to 10Hz Voltage Noise*. The noise voltage of the REF31xx increases with output voltage and operating temperature. Additional filtering may be used to improve output noise levels, although care should be taken to ensure the output impedance does not degrade the AC performance.

LONG-TERM STABILITY

Long-term stability refers to the change of the output voltage of a reference over a period of months or years. This effect lessens as time progresses, as is shown by the long-term stability curves. The typical drift value for the REF31xx is 70ppm from 0-1000 hours. This parameter is characterized by measuring 30 units at regular intervals for a period of 1000 hours.

LOAD REGULATION

Load regulation is defined as the change in output voltage due to changes in load current. The load regulation of the REF31xx is measured using force and sense contacts as pictured in Figure 4. The force and sense lines reduce the impact of contact and trace resistance, resulting in accurate measurement of the load regulation contributed solely by the REF31xx. For applications requiring improved load regulation, force and sense lines should be used.

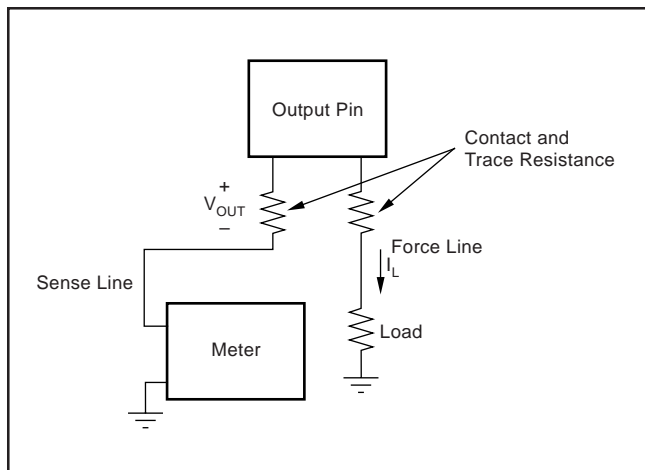


FIGURE 4. Accurate Load Regulation of REF31xx.

APPLICATION CIRCUITS

Negative Reference Voltage

For applications requiring a negative and positive reference voltage, the REF31xx and OPA703 can be used to provide a dual supply reference from a $\pm 5V$ supply. Figure 5 shows the REF3125 used to provide a $\pm 2.5V$ supply reference voltage. The low drift performance of the REF31xx complement the low offset voltage and low drift of the OPA703 to provide an accurate solution for split-supply applications.

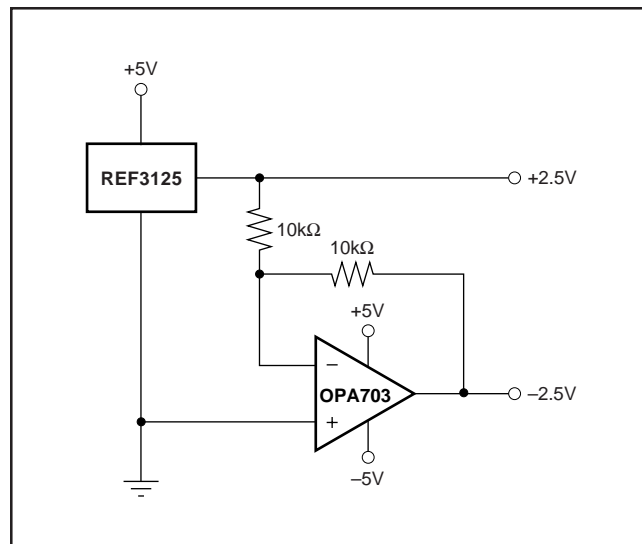


FIGURE 5. REF3125 Combined with OPA703 to Create Positive and Negative Reference Voltages.

DATA ACQUISITION

Data acquisition systems often require stable voltage references to maintain accuracy. The REF31xx family features stability and a wide range of voltages suitable for most micro-controllers and data converters. Figure 6, Figure 7, and Figure 8 show basic data acquisition systems.

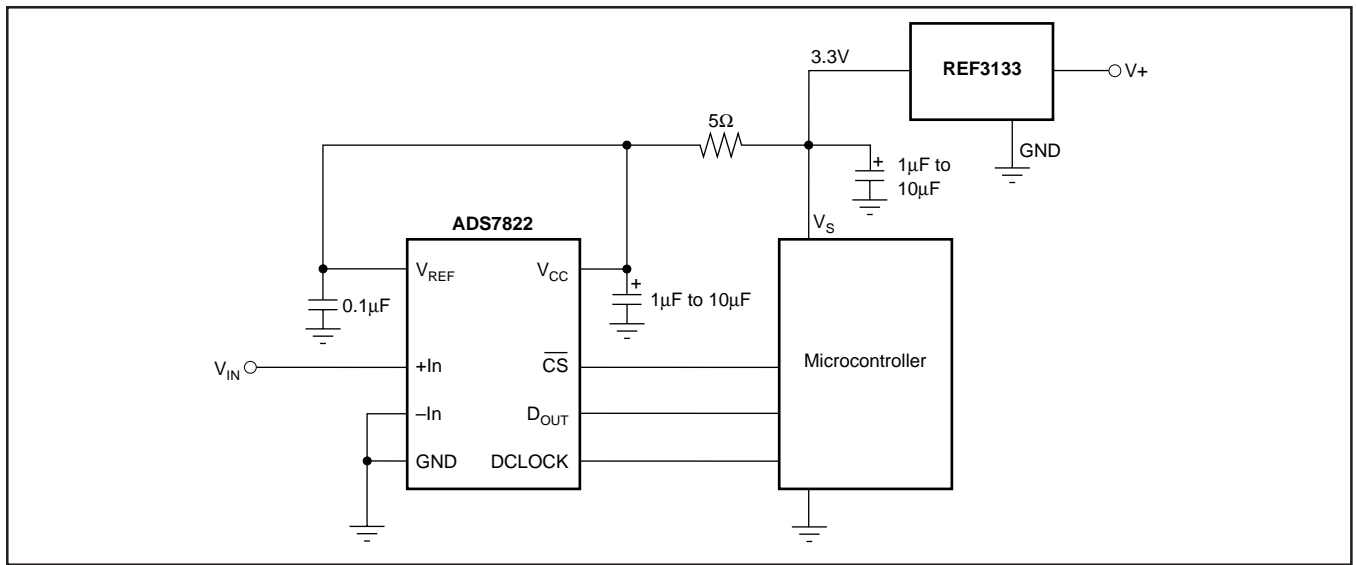


FIGURE 6. Basic Data Acquisition System 1.

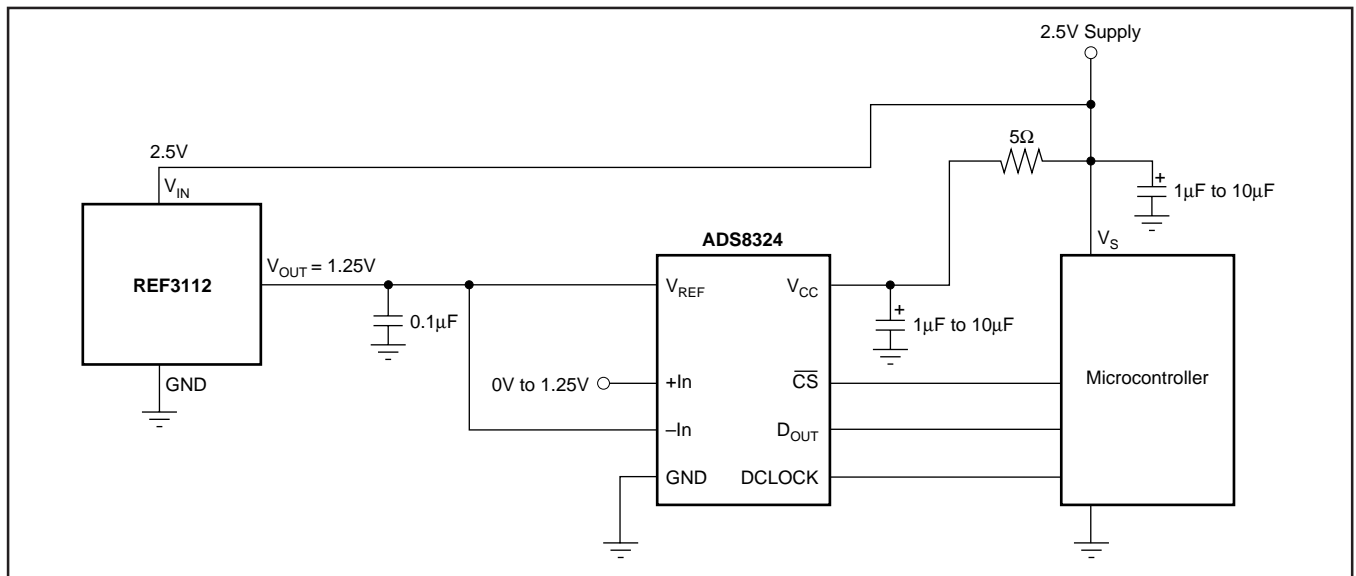


FIGURE 7. Basic Data Acquisition System 2.

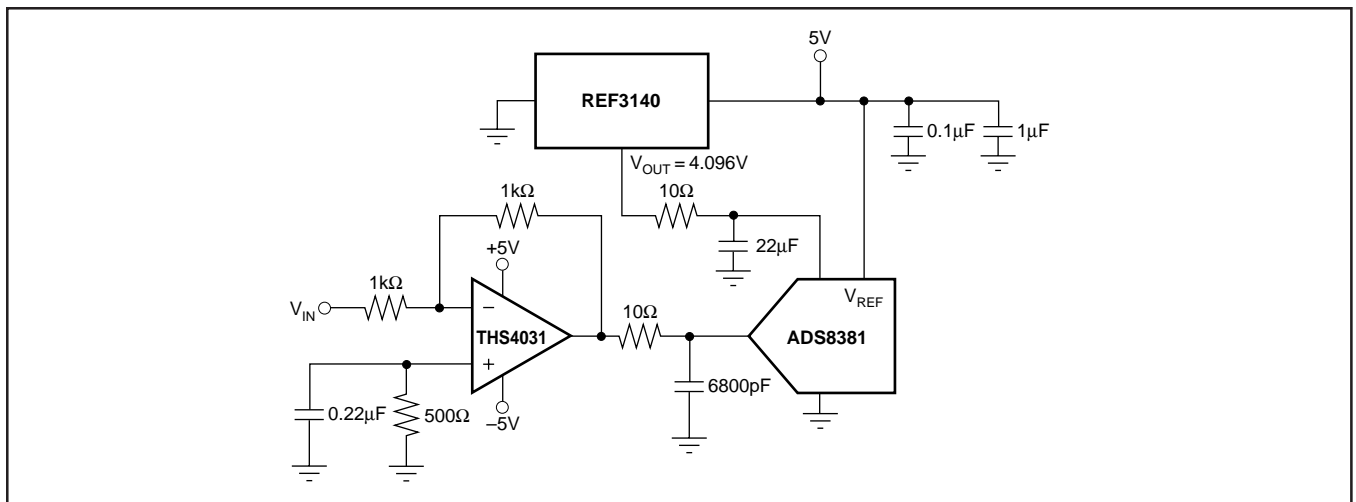
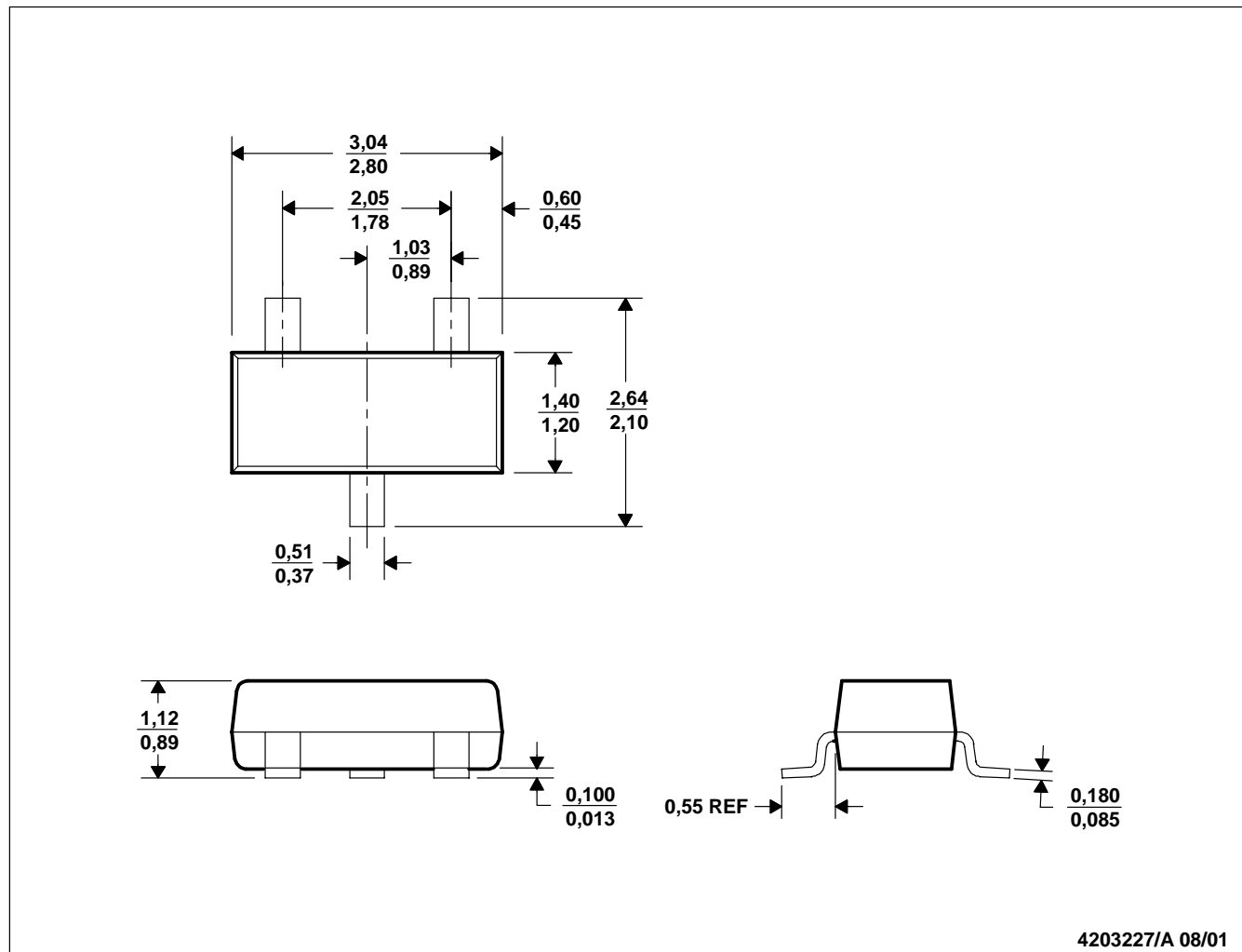


FIGURE 8. REF3140 Provides an Accurate Reference for Driving the ADS8381.

DBZ (R-PDSO-G3)

PLASTIC SMALL-OUTLINE



- NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Dimensions are inclusive of plating.
D. Dimensions are exclusive of mold flash and metal burr.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

| Products | | Applications | |
|------------------|--|---------------------|--|
| Amplifiers | amplifier.ti.com | Audio | www.ti.com/audio |
| Data Converters | dataconverter.ti.com | Automotive | www.ti.com/automotive |
| DSP | dsp.ti.com | Broadband | www.ti.com/broadband |
| Interface | interface.ti.com | Digital Control | www.ti.com/digitalcontrol |
| Logic | logic.ti.com | Military | www.ti.com/military |
| Power Mgmt | power.ti.com | Optical Networking | www.ti.com/opticalnetwork |
| Microcontrollers | microcontroller.ti.com | Security | www.ti.com/security |
| | | Telephony | www.ti.com/telephony |
| | | Video & Imaging | www.ti.com/video |
| | | Wireless | www.ti.com/wireless |

Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265

Copyright © 2004, Texas Instruments Incorporated