

## 4 ppm/°C, 100 $\mu$ A SOT23-6 SERIES VOLTAGE REFERENCES

 Check for Samples: [REF3212-EP](#), [REF3220-EP](#), [REF3225-EP](#), [REF3230-EP](#), [REF3233-EP](#), [REF3240-EP](#)

### FEATURES

- **Excellent Specified Drift Performance:**
  - 7ppm/°C (Max) at 0°C to 125°C
  - 20ppm/°C (Max) at –40°C to 125°C
  - 40ppm/°C (Max) at –55°C to 125°C
- **Microsize Package: SOT23-6**
- **High Output Current:  $\pm$ 10 mA**
- **High Accuracy: 0.01%**
- **Low Quiescent Current: 100  $\mu$ A**
- **Low Dropout: 5 mV**

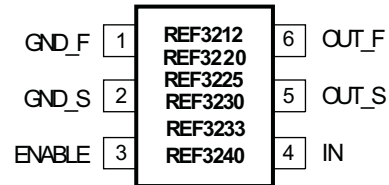
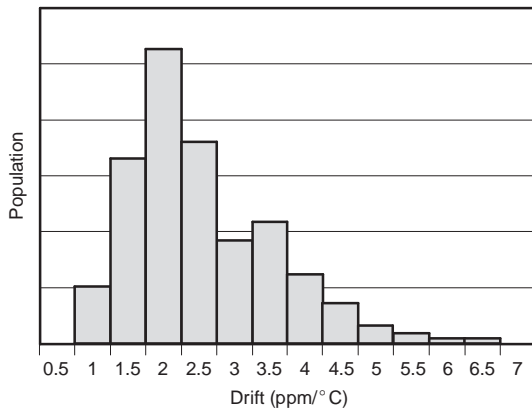
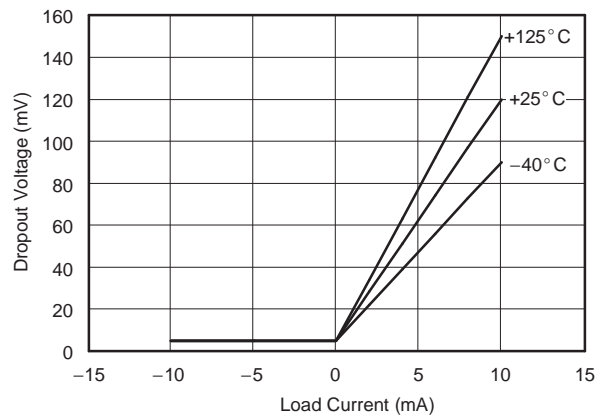
### SUPPORTS DEFENSE, AEROSPACE, AND MEDICAL APPLICATIONS

- **Controlled Baseline**
- **One Assembly/Test Site**
- **One Fabrication Site**
- **Available in Military (–55°C/125°C) Temperature Range<sup>(1)</sup>**
- **Extended Product Life Cycle**
- **Extended Product-Change Notification**
- **Product Traceability**

(1) Additional temperature ranges are available - contact factory

### APPLICATIONS

- **Portable Equipment**
- **Data Acquisition Systems**
- **Medical Equipment**
- **Test Equipment**


 TEMPERATURE DRIFT  
(0°C to +125°C)

 DROPOUT VOLTAGE  
vs LOAD CURRENT


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.

## DESCRIPTION

The REF32xx is a very low drift, micropower, low-dropout, precision voltage reference family available in the tiny SOT23-6 package.

The small size and low power consumption (120  $\mu$ A max) of the REF32xx make it ideal for portable and battery-powered applications. This reference is stable with most capacitive loads.

The REF32xx can be operated from a supply as low as 5 mV above the output voltage, under no load conditions. All models are specified for the wide temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

### AVAILABLE OUTPUT VOLTAGES

| PRODUCT | VOLTAGE |
|---------|---------|
| REF3212 | 1.25 V  |
| REF3220 | 2.048 V |
| REF3225 | 2.5 V   |
| REF3230 | 3 V     |
| REF3233 | 3.3 V   |
| REF3240 | 4.096 V |

**Table 1. PACKAGE/ORDERING INFORMATION<sup>(1)</sup>**

| PRODUCT         | OUTPUT VOLTAGE | PACKAGE-LEAD | PACKAGE DESIGNATOR <sup>(2)</sup> | PACKAGE MARKING |
|-----------------|----------------|--------------|-----------------------------------|-----------------|
| REF3212AMDBVREP | 1.25 V         | SOT23-6      | DBV                               | R3AM            |
| REF3220AMDBVREP | 2.048 V        | SOT23-6      | DBV                               | R3BM            |
| REF3225AMDBVREP | 2.5 V          | SOT23-6      | DBV                               | R3CM            |
| REF3230AMDBVREP | 3 V            | SOT23-6      | DBV                               | R3DM            |
| REF3233AMDBVREP | 3.3 V          | SOT23-6      | DBV                               | R3EM            |
| REF3240AMDBVREP | 4.096 V        | SOT23-6      | DBV                               | R3FM            |

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at [www.ti.com](http://www.ti.com).

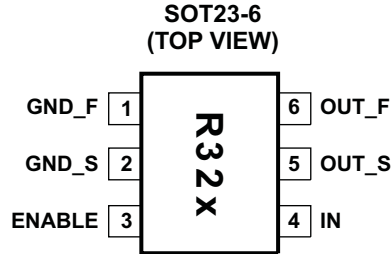
(2) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).



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.

**Figure 1. PIN CONFIGURATION**



A. The location of pin 1 on the REF32xx is determined by orienting the package marking as shown.

**PIN DESCRIPTIONS**

| PIN    |     | FUNCTION      | DESCRIPTION                              |
|--------|-----|---------------|--|
| NAME   | NO. |               |  |
| ENABLE | 3   | Digital input | This pin enables and disables the device |
| GND_F  | 1   | Analog output | Ground connection of the device          |
| GND_S  | 2   | Analog input  | Ground sense at the load                 |
| IN     | 4   | Analog input  | Positive supply voltage                  |
| OUT_F  | 6   | Analog output | Output of Reference Voltage              |
| OUT_S  | 5   | Analog input  | Sense connection at the load             |

**Absolute Maximum Ratings<sup>(1)</sup>**

|                             | MIN                  | MAX                | UNIT |
|-----------------------------|----------------------|--------------------|------|
| Input voltage               |                      | 7.5                | V    |
| Output short-circuit        | Continuous           |                    |      |
| Operating temperature range | -55                  | 125                | °C   |
| Storage temperature range   | -65                  | 150 <sup>(2)</sup> | °C   |
| Junction temperature        |                      | 150                | °C   |
| ESD rating                  | Human-Body Model     | 4                  | kV   |
|                             | Charged-Device Model | 1                  |      |
|                             | Machine Model        | 400                | V    |

(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.

(2) Long-term high-temperature storage and/or extended use at maximum recommended operating conditions may result in a reduction of overall device life. See [http://www.ti.com/ep\\_quality](http://www.ti.com/ep_quality) for additional information on enhanced plastic packaging.

## Electrical Characteristics

Boldface limits apply over the listed temperature range.

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

| PARAMETER  |                                   | TEST CONDITIONS  | MIN  | TYP   | MAX    | UNIT                       |                         |
|--|-----------------------------------|--|--|-------|--------|----------------------------|-------------------------|
| <b>REF3212 (1.25 V)</b>                                |                                   |  |  |       |        |                            |                         |
| $V_{\text{OUT}}$                                       | Output voltage                    |  | 1.2475   | 1.25  | 1.2525 | V                          |                         |
|  | Initial accuracy                  |  | -0.2   | 0.01  | 0.2    | %                          |                         |
| Noise  | Output voltage noise              | $f = 0.1\text{ Hz to }10\text{ Hz}$                                |  | 17    |        | $\mu\text{V}_{\text{PP}}$  |                         |
|  | Voltage noise                     | $f = 10\text{ Hz to }10\text{ kHz}$                                |  | 24    |        | $\mu\text{V}_{\text{RMS}}$ |                         |
| <b>REF3220 (2.048 V)</b>                               |                                   |  |  |       |        |                            |                         |
| $V_{\text{OUT}}$                                       | Output voltage                    |  | 2.044  | 2.048 | 2.052  | V                          |                         |
|  | Initial accuracy                  |  | -0.2   | 0.01  | 0.2    | %                          |                         |
| Noise  | Output voltage noise              | $f = 0.1\text{ Hz to }10\text{ Hz}$                                |  | 27    |        | $\mu\text{V}_{\text{PP}}$  |                         |
|  | Voltage noise                     | $f = 10\text{ Hz to }10\text{ kHz}$                                |  | 39    |        | $\mu\text{V}_{\text{RMS}}$ |                         |
| <b>REF3225 (2.5 V)</b>                                 |                                   |  |  |       |        |                            |                         |
| $V_{\text{OUT}}$                                       | Output voltage                    |  | 2.495  | 2.5   | 2.505  | V                          |                         |
|  | Initial accuracy                  |  | -0.2   | 0.01  | 0.2    | %                          |                         |
| Noise  | Output voltage noise              | $f = 0.1\text{ Hz to }10\text{ Hz}$                                |  | 33    |        | $\mu\text{V}_{\text{PP}}$  |                         |
|  | Voltage noise                     | $f = 10\text{ Hz to }10\text{ kHz}$                                |  | 48    |        | $\mu\text{V}_{\text{RMS}}$ |                         |
| <b>REF3230 (3 V)</b>                                   |                                   |  |  |       |        |                            |                         |
| $V_{\text{OUT}}$                                       | Output voltage                    |  | 2.994  | 3     | 3.006  | V                          |                         |
|  | Initial accuracy                  |  | -0.2   | 0.01  | 0.2    | %                          |                         |
| Noise  | Output voltage noise              | $f = 0.1\text{ Hz to }10\text{ Hz}$                                |  | 39    |        | $\mu\text{V}_{\text{PP}}$  |                         |
|  | Voltage noise                     | $f = 10\text{ Hz to }10\text{ kHz}$                                |  | 57    |        | $\mu\text{V}_{\text{RMS}}$ |                         |
| <b>REF3233 (3.3 V)</b>                                 |                                   |  |  |       |        |                            |                         |
| $V_{\text{OUT}}$                                       | Output voltage                    |  | 3.293  | 3.3   | 3.307  | V                          |                         |
|  | Initial accuracy                  |  | -0.2   | 0.01  | 0.2    | %                          |                         |
| Noise  | Output voltage noise              | $f = 0.1\text{ Hz to }10\text{ Hz}$                                |  | 43    |        | $\mu\text{V}_{\text{PP}}$  |                         |
|  | Voltage noise                     | $f = 10\text{ Hz to }10\text{ kHz}$                                |  | 63    |        | $\mu\text{V}_{\text{RMS}}$ |                         |
| <b>REF3240 (4.096 V)</b>                               |                                   |  |  |       |        |                            |                         |
| $V_{\text{OUT}}$                                       | Output voltage                    |  | 4.088  | 4.096 | 4.104  | V                          |                         |
|  | Initial accuracy                  |  | -0.2   | 0.01  | 0.2    | %                          |                         |
| Noise  | Output voltage noise              | $f = 0.1\text{ Hz to }10\text{ Hz}$                                |  | 53    |        | $\mu\text{V}_{\text{PP}}$  |                         |
|  | Voltage noise                     | $f = 10\text{ Hz to }10\text{ kHz}$                                |  | 78    |        | $\mu\text{V}_{\text{RMS}}$ |                         |
| <b>REF3212/REF3220/REF3225/REF3230/REF3233/REF3240</b> |                                   |  |  |       |        |                            |                         |
| $dV_{\text{OUT}}/dT$                                   | Output voltage temperature drift  | $T_A = 25^\circ\text{C}$   |  | 4     | 7      | ppm/ $^\circ\text{C}$      |                         |
|  |                                   | $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$                |  | 10.5  | 40     |                            |                         |
|  | Long-term stability               | 0 tp 1000 h  |  | 55    |        | ppm                        |                         |
|  | Line regulation                   | $V_{\text{OUT}} + 0.05^{(1)} \leq V_{\text{IN}} \leq 5.5\text{ V}$ | -65  | 15    | 65     | ppm/V                      |                         |
| $dV_{\text{OUT}}/dI_{\text{LOAD}}$                     | Load regulation <sup>(2)</sup>    | Sourcing   | $0\text{ mA} < I_{\text{LOAD}} < 10\text{ mA}$ , $V_{\text{IN}} = V_{\text{OUT}} + 250\text{ mV}^{(1)}$  | -40   | 3      | 40                         | $\mu\text{V}/\text{mA}$ |
|  |                                   | Sinking  | $-10\text{ mA} < I_{\text{LOAD}} < 0\text{ mA}$ , $V_{\text{IN}} = V_{\text{OUT}} + 100\text{ mV}^{(1)}$ | -60   | 20     | 60                         |                         |
| $dT$   | Thermal hysteresis <sup>(3)</sup> | First cycle  |  | 100   |        | ppm                        |                         |
|  |                                   | Additional cycles  |  | 25    |        |                            |                         |
| $V_{\text{IN}} - V_{\text{OUT}}$                       | Dropout voltage <sup>(1)</sup>    | $25^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$                |  | 5     | 50     | mV                         |                         |

(1) The minimum supply voltage for the REF3212 is 1.8 V.

(2) Load regulation is using force and sense lines; see the *Load Regulation* section for more information.

(3) Thermal hysteresis procedure is explained in more detail in the *Applications Information* section.

### Electrical Characteristics (continued)

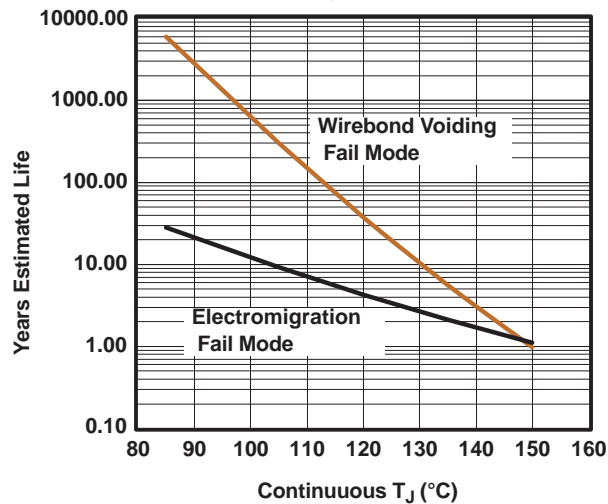
Boldface limits apply over the listed temperature range.

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

| PARAMETER             |                                | TEST CONDITIONS   | MIN                           | TYP        | MAX             | UNIT               |
|-----------------------|--------------------------------|---|-------------------------------|------------|-----------------|--------------------|
| $I_{\text{LOAD}}$     | Output current                 | $V_{\text{IN}} = V_{\text{OUT}} + 250 \text{ mV}^{(1)}$ | -10                           |            | 10              | mA                 |
| $I_{\text{SC}}$       | Short-circuit current          | Sourcing  |                               | 50         |                 | mA                 |
|                       |                                | Sinking   |                               | 40         |                 |                    |
| Turn-on settling time |                                | 0.1% at $V_{\text{IN}} = 5 \text{ V}$ with $C_L = 0$    |                               | 60         |                 | $\mu\text{s}$      |
| $V_L$                 | Enable/shutdown <sup>(4)</sup> | Reference in shutdown mode                              | 0                             |            | 0.7             | V                  |
| $V_H$                 |                                | Reference is active                                     | 1.5                           |            | $V_{\text{IN}}$ |                    |
| $V_{\text{IN}}$       | Power supply Voltage           | $I_L = 0$   | $V_{\text{OUT}} + 0.05^{(1)}$ |            | 5.5             | V                  |
| $I_Q$                 | Power supply Current           | $I_L = 0$ , ENABLE > 1.5 V                              |                               | 100        | 120             | $\mu\text{A}$      |
| $I_S$                 | Overtemperature shutdown       | $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$     |                               | <b>115</b> | <b>135</b>      | $\mu\text{A}$      |
|                       |                                | ENABLE < 0.7 V  |                               | 0.1        | 1               | $\mu\text{A}$      |
| Temperature range     | Specified                      |   | -55                           |            | 125             | $^\circ\text{C}$   |
|                       | Operating                      |   | -55                           |            | 125             |                    |
|                       | Storage                        |   | -65                           |            | 150             |                    |
| $\theta_{\text{JA}}$  | Thermal resistance, SOT23-6    |   |                               | 200        |                 | $^\circ\text{C/W}$ |

(4) If the rise time of the input voltage is less than or equal to 2ms, the ENABLE and IN pins can be tied together. For rise times greater than 2ms, see the [Supply Voltage](#) section.

Figure 2. Operating Life Derating Chart

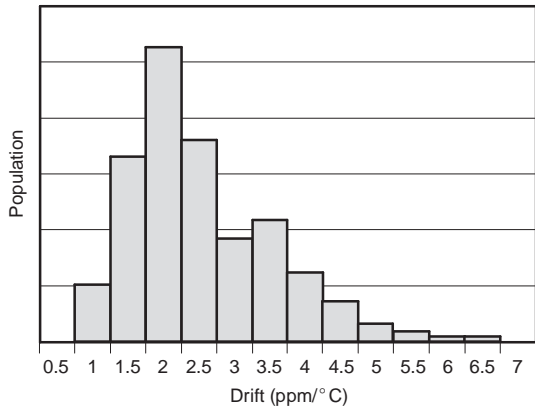


- A. See Datasheet for Absolute Maximum and Minimum Recommended Operating Conditions.
- B. Silicon Operating Life Design Goal is 10 years at  $105^\circ\text{C}$  Junction Temperature (does not include package interconnect life).
- C. Enhanced Plastic Product Disclaimer Applies.

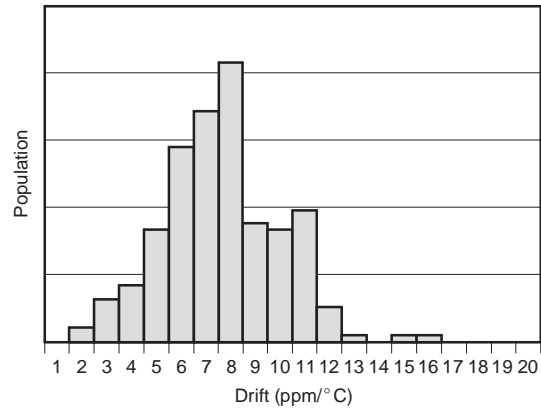
**TYPICAL CHARACTERISTICS**

$T_A = 25^\circ\text{C}$ ,  $I_{\text{LOAD}} = 0 \text{ mA}$ ,  $V_{\text{IN}} = 5 \text{ V}$  power supply, REF3225 is used for typical characteristics (unless otherwise noted)

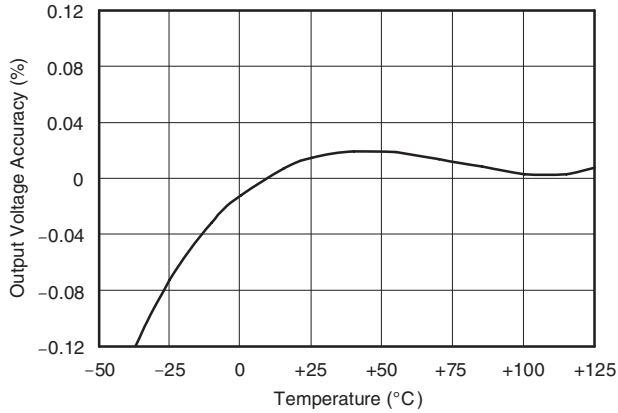
TEMPERATURE DRIFT  
 (0° C to +125° C)



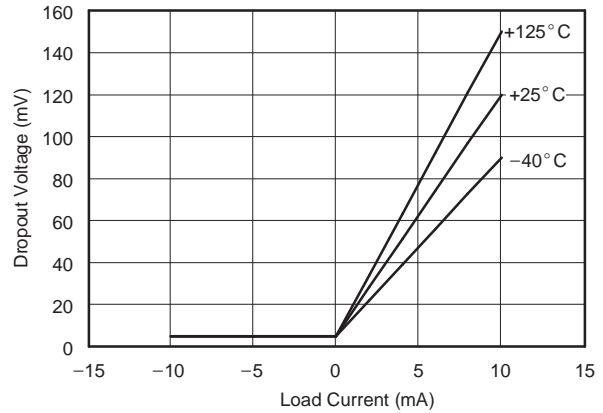
TEMPERATURE DRIFT  
 (-40° C to +125° C)



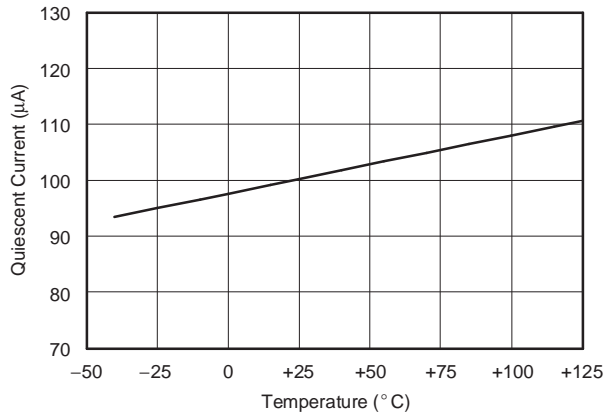
OUTPUT VOLTAGE ACCURACY  
 vs TEMPERATURE



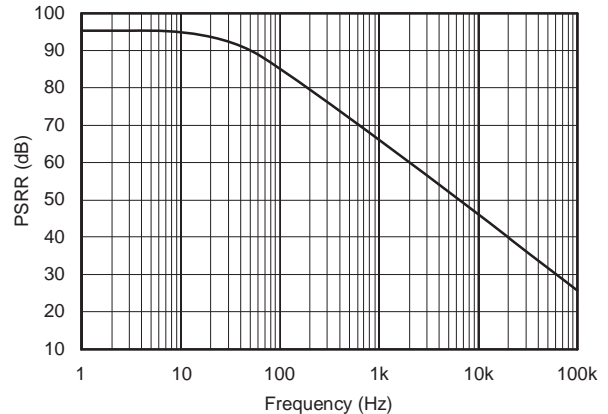
DROPOUT VOLTAGE  
 vs LOAD CURRENT



QUIESCENT CURRENT  
 vs TEMPERATURE



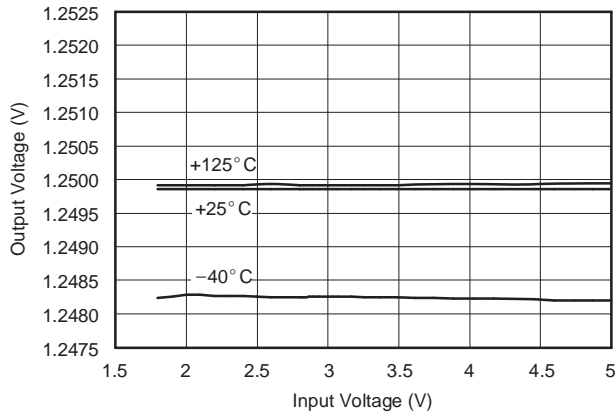
POWER-SUPPLY REJECTION RATIO  
 vs FREQUENCY



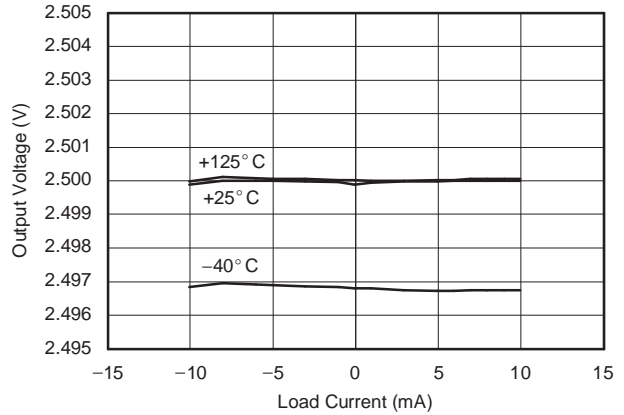
**TYPICAL CHARACTERISTICS (continued)**

$T_A = 25^\circ\text{C}$ ,  $I_{\text{LOAD}} = 0 \text{ mA}$ ,  $V_{\text{IN}} = 5 \text{ V}$  power supply, REF3225 is used for typical characteristics (unless otherwise noted)

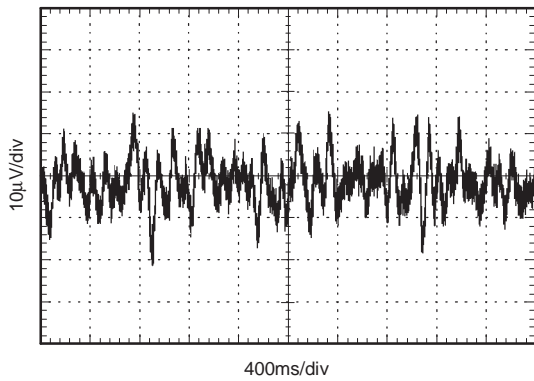
OUTPUT VOLTAGE vs INPUT VOLTAGE  
(REF3212)



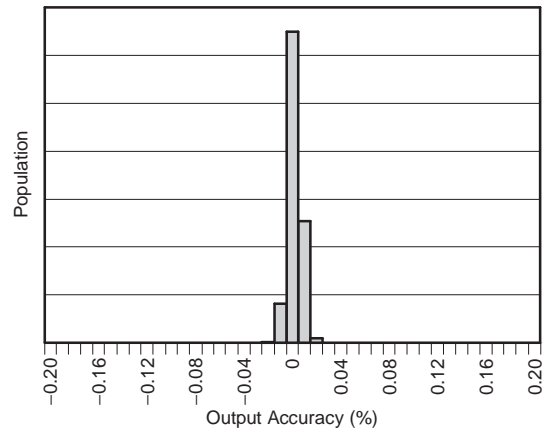
OUTPUT VOLTAGE vs LOAD CURRENT



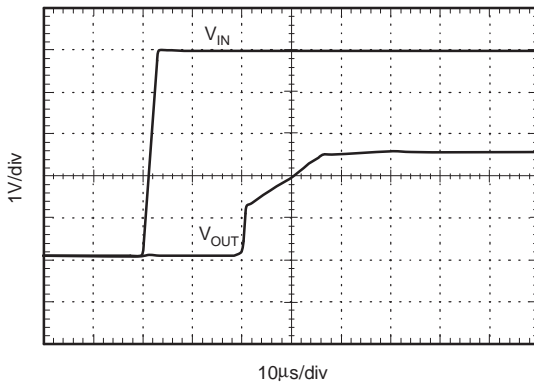
0.1Hz TO 10Hz  
NOISE



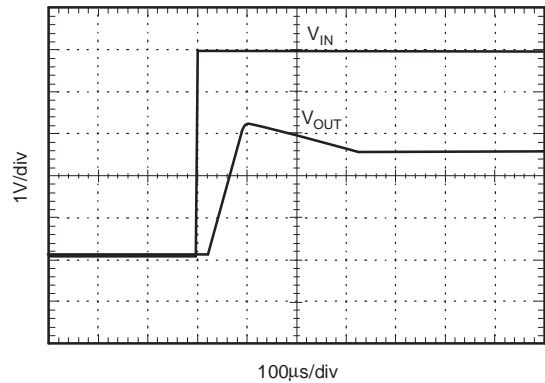
OUTPUT VOLTAGE  
INITIAL ACCURACY



STEP RESPONSE  
 $C_L = 0\text{pF}$ , 5V STARTUP

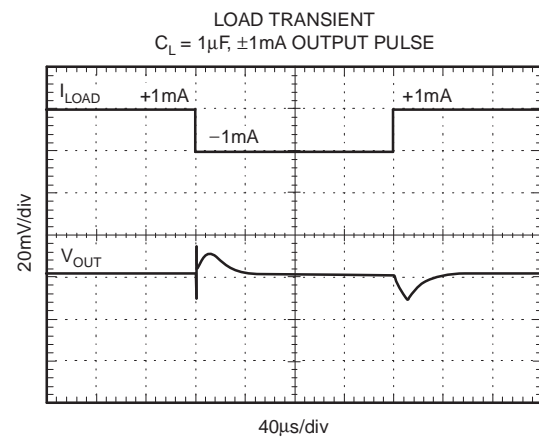
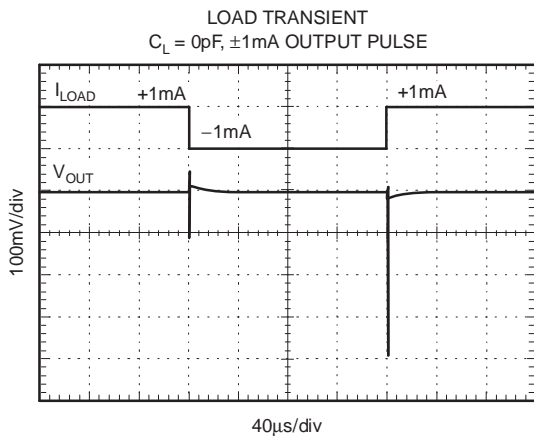
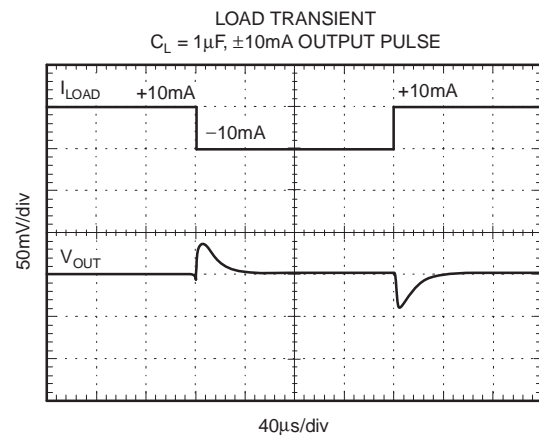
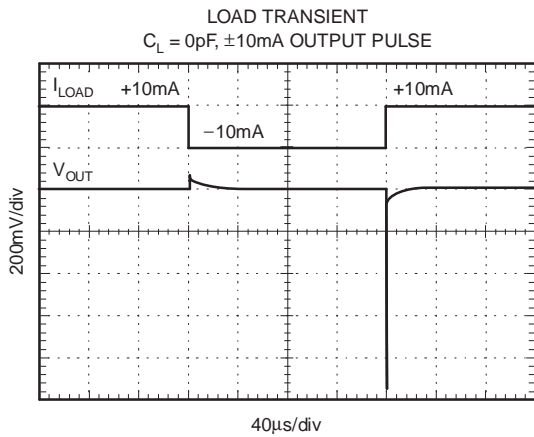
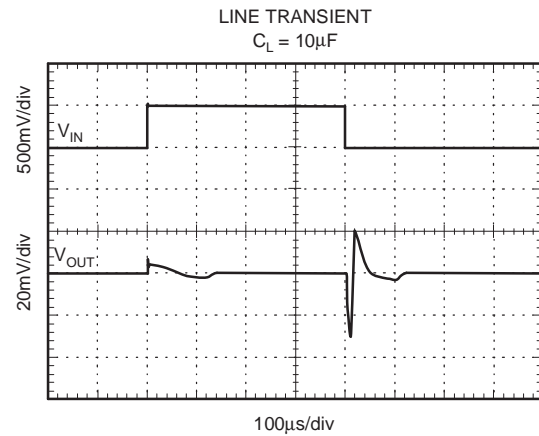
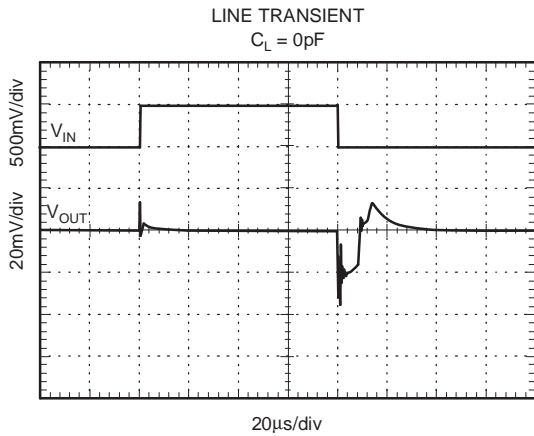


STEP RESPONSE  
 $C_L = 1\mu\text{F}$



**TYPICAL CHARACTERISTICS (continued)**

$T_A = 25^\circ\text{C}$ ,  $I_{\text{LOAD}} = 0\text{ mA}$ ,  $V_{\text{IN}} = 5\text{ V}$  power supply, REF3225 is used for typical characteristics (unless otherwise noted)

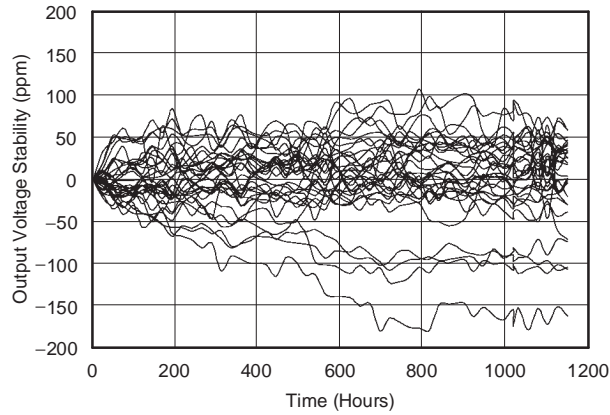




### TYPICAL CHARACTERISTICS (continued)

$T_A = 25^\circ\text{C}$ ,  $I_{\text{LOAD}} = 0\text{ mA}$ ,  $V_{\text{IN}} = 5\text{ V}$  power supply, REF3225 is used for typical characteristics (unless otherwise noted)

LONG-TERM STABILITY  
(32 Units)



### THEORY OF OPERATION

The REF32xx is a family of CMOS, precision bandgap voltage references. Figure 3 shows the basic bandgap topology. Transistors  $Q_1$  and  $Q_2$  are biased so that the current density of  $Q_1$  is greater than that of  $Q_2$ . The difference of the two base-emitter voltages ( $V_{be_1} - V_{be_2}$ ) has a positive temperature coefficient and is forced across resistor  $R_1$ . This voltage is amplified 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.

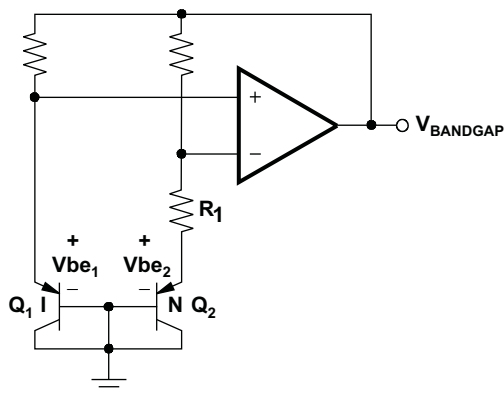


Figure 3. Simplified Schematic of Bandgap Reference

## APPLICATION INFORMATION

The REF32xx does not require a load capacitor and is stable with most capacitive loads, see Load Capacitance Guidelines. Figure 4 shows typical connections required for operation of the REF32xx. A supply bypass capacitor of 0.47  $\mu\text{F}$  is recommended.

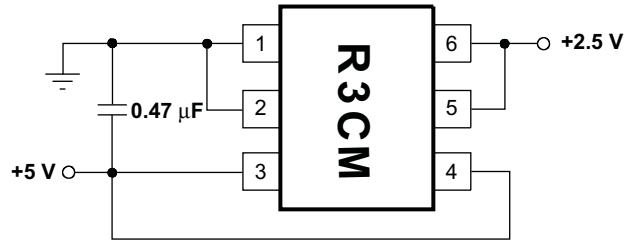


Figure 4. Typical Operating Connections for the REF3225

### Supply Voltage

The REF32xx family of references features an extremely low dropout voltage. With the exception of the REF3212, which has a minimum supply requirement of 1.8 V, these references can be operated with a supply of only 5 mV above the output voltage in an unloaded condition. For loaded conditions, a typical dropout voltage versus load is shown in the Typical Characteristic curves.

The REF32xx also features a low quiescent current of 100  $\mu\text{A}$ , with a maximum quiescent current over temperature of 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 5.

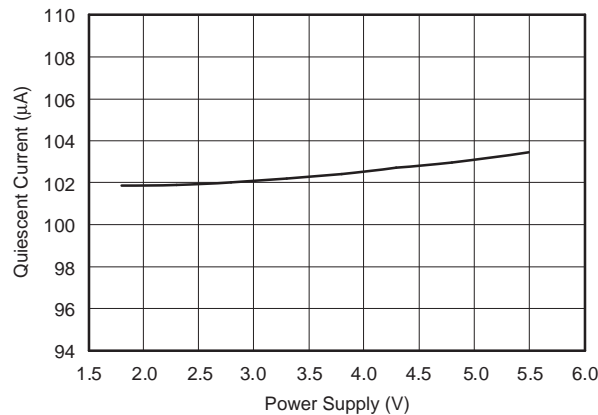
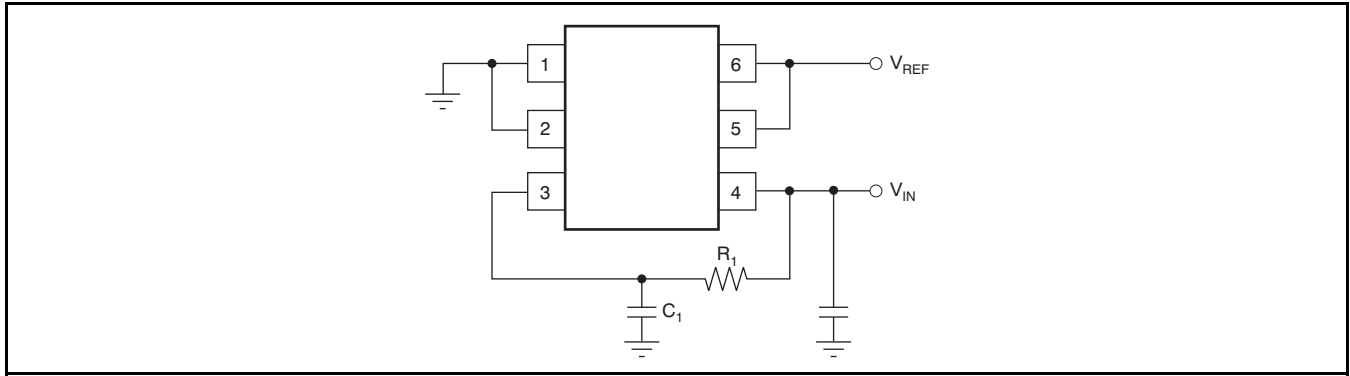


Figure 5. Supply Current vs Supply Voltage

Supply voltages below the specified levels can cause the REF32xx to momentarily draw currents greater than the typical quiescent current. This momentary current draw can be prevented by using a power supply with a fast rising edge and low output impedance.

For optimal startup when the IN pin and ENABLE pin are tied together, keep the input voltage rise time less than or equal to 2ms. For rise times greater than 2ms, the ENABLE pin must be kept below 0.7V until the voltage at the IN pin has reached the minimum operating voltage. One way to control the voltage at the ENABLE pin is with an additional RC filter, such as that shown in Figure 6. The RC filter must hold the voltage at the ENABLE pin below the threshold voltage until the voltage at the input pin has reached the minimum operating voltage.



**Figure 6. Application Circuit to Control the REF32xx ENABLE Pin**

The RC filter in [Figure 6](#) can be used as a starting point for the REF3240. The values for  $R_1$  and  $C_1$  have been calculated so that the voltage at the ENABLE pin reaches 0.7V after the input voltage has reached 4.15V; [Table 2](#) lists these values. For output voltage options other than 4.096V, the RC filter can be made faster.

**Table 2. Recommended  $R_1$  and  $C_1$  Values for the REF3240**

| RISE TIME | $R_1$ VALUE   | $C_1$ VALUE |
|-----------|---------------|-------------|
| 2ms       | 150k $\Omega$ | 100nF       |
| 5ms       | 150k $\Omega$ | 220nF       |
| 10ms      | 330k $\Omega$ | 220nF       |
| 20ms      | 390k $\Omega$ | 330nF       |
| 50ms      | 680k $\Omega$ | 470nF       |
| 100ms     | 680k $\Omega$ | 1000nF      |

In this document, rise time is defined as the time until an exponential input signal reaches 90% of its final voltage. For example, the 2ms value shown in [Table 2](#) is valid for an end value of 5V.

If the input voltage has a different shape or the end value is not 5V, then the time until the minimum dropout voltage has been reached should be used to decide if the IN and ENABLE pins can be tied together. [Table 3](#) lists these times.

**Table 3. Minimum Dropout Voltage Times**

| DEVICE  | TIME  |
|---------|-------|
| REF3212 | 0.4ms |
| REF3220 | 0.5ms |
| REF3225 | 0.7ms |
| REF3230 | 0.9ms |
| REF3233 | 1.0ms |
| REF3240 | 1.6ms |

Note that because the leakage current of the EN pin is in the range of a few nA, it can be disregarded in most applications.

## Shutdown

The REF32xx can be placed in a low-power mode by pulling the ENABLE/SHUTDOWN pin low. When in shutdown mode the output of the REF32xx becomes a resistive load to ground. The value of the load depends on the model, and ranges from approximately 100 kΩ to 400 kΩ.

The ENABLE pin must always be driven to a valid voltage level ( $V_L$  or  $V_H$ ) as shown in the Electrical Characteristics section of this datasheet. To maintain the low quiescent current (100 μA typ), the ENABLE pin was designed without an internal pull-up resistor. In applications where the shutdown feature will not be used, connecting the ENABLE pin high (to the IN pin) will ensure enabled operation of the device.

## Thermal Hysteresis

Thermal hysteresis for the REF32xx 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:

$$V_{\text{HYST}} = \left( \frac{|V_{\text{PRE}} - V_{\text{POST}}|}{V_{\text{NOM}}} \right) \times 10^6 (\text{ppm}) \quad (1)$$

Where:

$V_{\text{HYST}}$  = Thermal hysteresis (in units of ppm)

$V_{\text{NOM}}$  = The specified output voltage

$V_{\text{PRE}}$  = Output voltage measured at 25°C pretemperature cycling

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

## Temperature Drift

The REF32xx is designed to exhibit minimal drift error, which is defined as the change in output voltage over varying temperature. The drift is calculated using the box method, as described by the following equation:

$$\text{Drift} = \left( \frac{V_{\text{OUTMAX}} - V_{\text{OUTMIN}}}{V_{\text{OUT}} \times \text{Temp Range}} \right) \times 10^6 (\text{ppm}) \quad (2)$$

The REF32xx features a typical drift coefficient of 4 ppm/°C from 0°C to 125°C — the primary temperature range for many applications. For the extended temperature range of –55°C to 125°C, the REF32xx family drift increases to a typical value of 10.5 ppm/°C.

## Noise Performance

Typical 0.1-Hz to 10-Hz voltage noise can be seen in the Typical Characteristic curve, *0.1-Hz to 10-Hz Voltage Noise*. The noise voltage of the REF32xx increases with output voltage and operating temperature. Additional filtering can be used to improve output noise levels, although care should be taken to ensure the output impedance does not degrade 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 Typical Characteristic curves. The typical drift value for the REF32xx is 55 ppm from 0 to 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 as a result of changes in load current. The load regulation of the REF32xx is measured using force and sense contacts, as shown in Figure 7. The force and sense lines can be used to effectively eliminate the impact of contact and trace resistance, resulting in accurate voltage at the load. By connecting the force and sense lines at the load, the REF32xx compensates for the contact and trace resistances because it measures and adjusts the voltage actually delivered at the load.

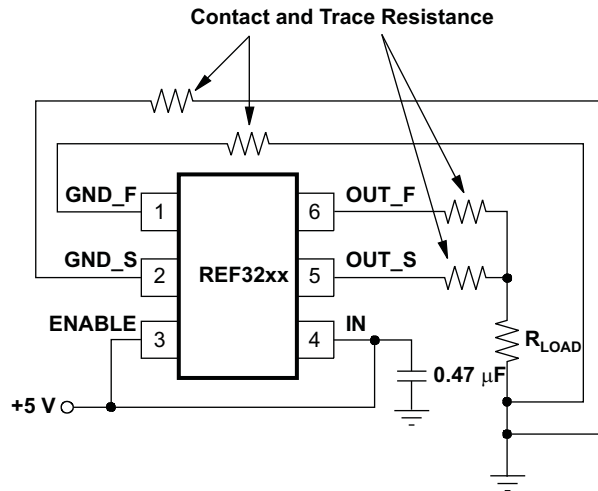


Figure 7. Accurate Load Regulation of REF32xx

The GND\_S pin is connected to the internal ground of the device through ESD protection diodes. Because of that connection, the maximum differential voltage between the GND\_S and GND\_F pins must be kept below 200mV to prevent these diodes from unintentionally turning on.

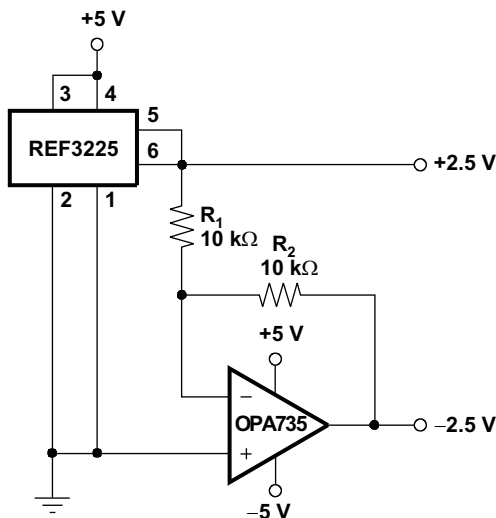
## Load Capacitance Guidelines

The REF32xx series is designed to be stable with most capacitive loads. Common load capacitance values range between 1 μF and 47 μF. To minimize noise and provide specified performance, all models will benefit from an ESR value above 1 Ω with capacitive loads higher than 10 μF. However, the REF3212 must have an ESR value above 1Ω with capacitive loads higher than 10 μF to avoid oscillation.

## APPLICATION CIRCUITS

### Negative Reference Voltage

For applications requiring a negative and positive reference voltage, the REF32xx and OPA735 can be used to provide a dual-supply reference from a 5-V supply. Figure 8 shows the REF3225 used to provide a 2.5-V supply reference voltage. The low drift performance of the REF32xx complements the low offset voltage and zero drift of the OPA735 to provide an accurate solution for split-supply applications. Care must be taken to match the temperature coefficients of  $R_1$  and  $R_2$ .



Note: Bypass capacitor is not shown.

Figure 8. REF3225 Combined With OPA735 to Create Positive and Negative Reference Voltages

### Data Acquisition

Data acquisition systems often require stable voltage references to maintain accuracy. The REF32xx family features stability and a wide range of voltages suitable for most microcontrollers and data converters. Figure 9, Figure 10, and Figure 11 show basic data acquisition systems.

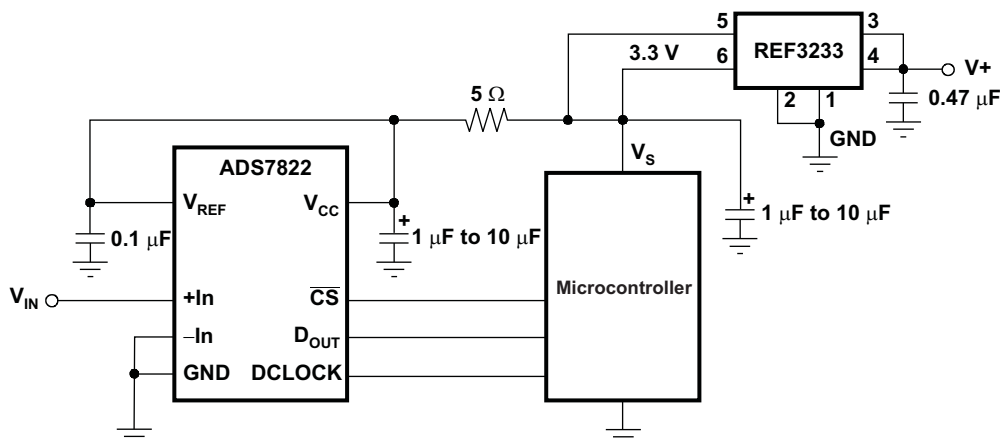


Figure 9. Basic Data Acquisition System 1

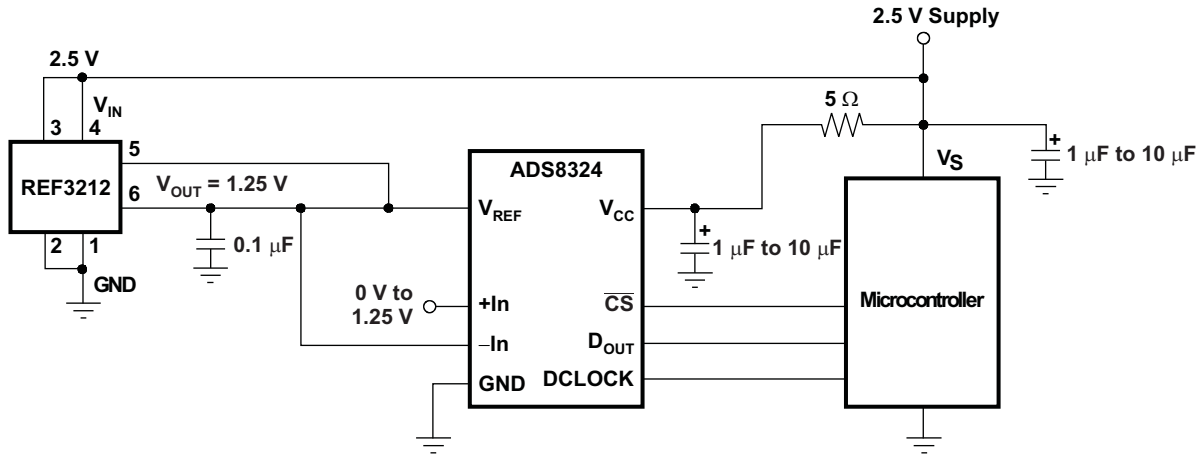


Figure 10. Basic Data Acquisition System 2

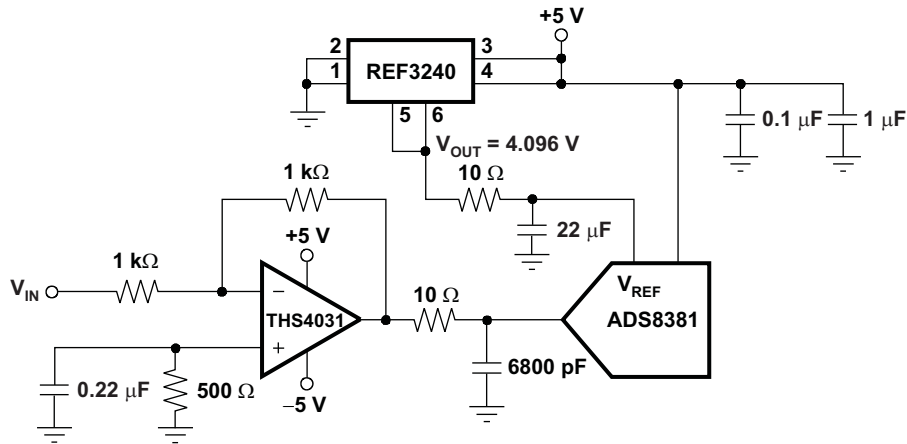


Figure 11. REF3240 Provides an Accurate Reference for Driving the ADS8381



**Changes from Revision A (April 2007) to Revision B****Page**

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|  |    |
|--|----|
| • Added Pin Descriptions table .....   | 3  |
| • Added note to Enable/Shutdown parameter .....  | 5  |
| • Changed the minimum voltage for Enable/Shutdown with reference active from $0.75 \times V_{IN}$ to 1.5 ..... | 5  |
| • Changed current test condition from $0.75 \times V_{IN}$ to 1.5 V .....                                      | 5  |
| • Added text, two tables and one figure to Supply Voltage section .....  | 11 |
| • Changed pin 3 in <a href="#">Figure 7</a> from SHDN to ENABLE (typo) .....                                   | 14 |
| • Added paragraph to Load Regulation section .....   | 14 |

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**PACKAGING INFORMATION**

| Orderable Device  | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup>    | Lead/<br>Ball Finish | MSL Peak Temp <sup>(3)</sup> | Samples<br>(Requires Login) |
|-------------------|-----------------------|--------------|-----------------|------|-------------|----------------------------|----------------------|------------------------------|-----------------------------|
| REF3212AMDBVREP   | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |
| REF3212AMDBVREPG4 | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |
| REF3220AMDBVREP   | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |
| REF3225AMDBVREP   | ACTIVE                | SOT-23       | DBV             | 6    | 250         | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |
| REF3225AMDBVREPG4 | ACTIVE                | SOT-23       | DBV             | 6    | 250         | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |
| REF3230AMDBVREP   | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |
| REF3230AMDBVREPG4 | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |
| REF3233AMDBVREP   | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |
| REF3233AMDBVREPG4 | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |
| REF3240AMDBVREP   | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |
| REF3240AMDBVREPG4 | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |
| V62/07602-01XE    | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |
| V62/07602-02XE    | ACTIVE                | SOT-23       | DBV             | 6    | 250         | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |
| V62/07602-03XE    | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |
| V62/07602-04XE    | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |
| V62/07602-05XE    | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |
| V62/07602-06XE    | ACTIVE                | SOT-23       | DBV             | 6    | 3000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-2-260C-1 YEAR          |                             |

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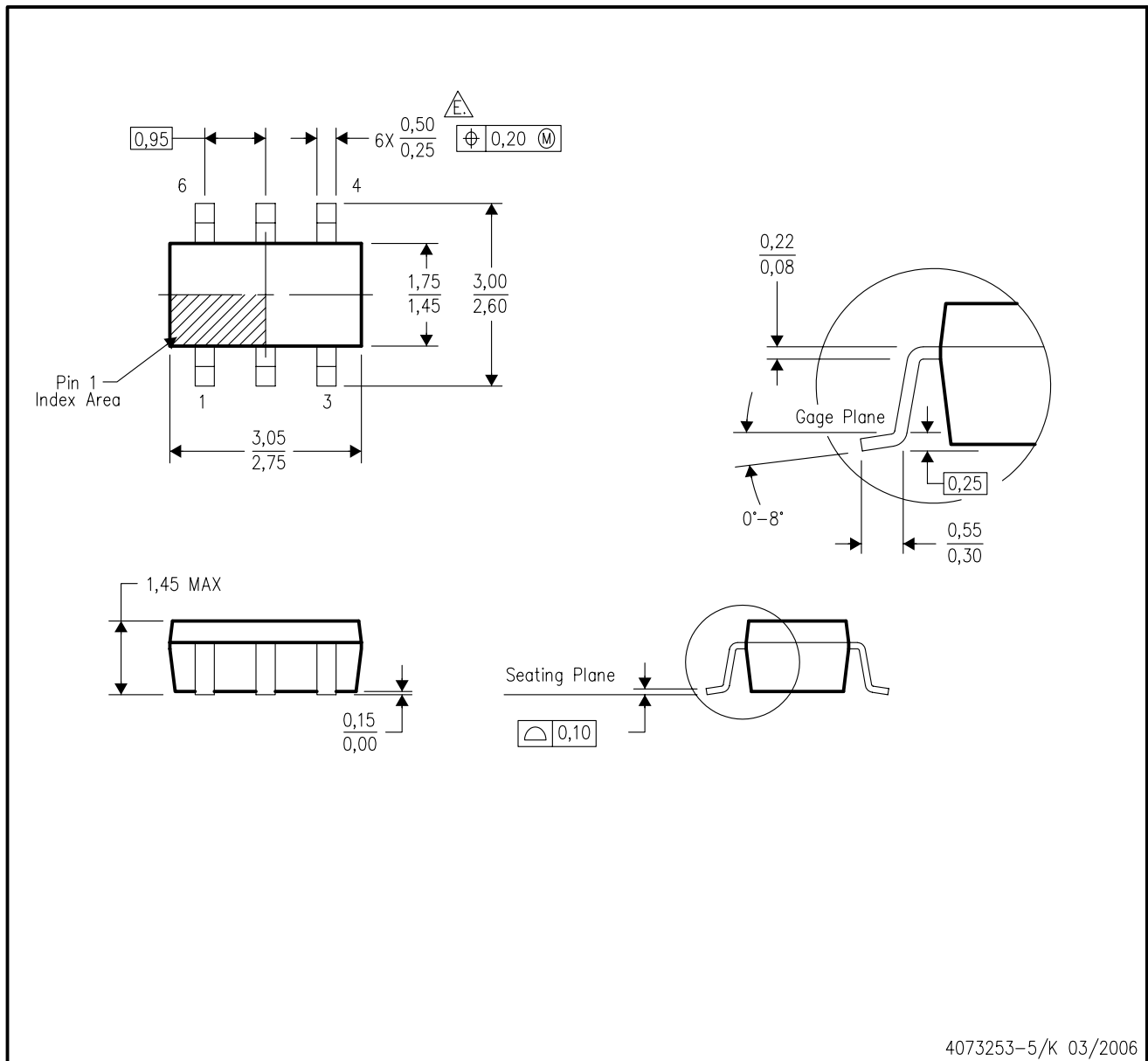
● Catalog: [REF3212](#), [REF3220](#), [REF3225](#), [REF3230](#), [REF3233](#), [REF3240](#)

NOTE: Qualified Version Definitions:

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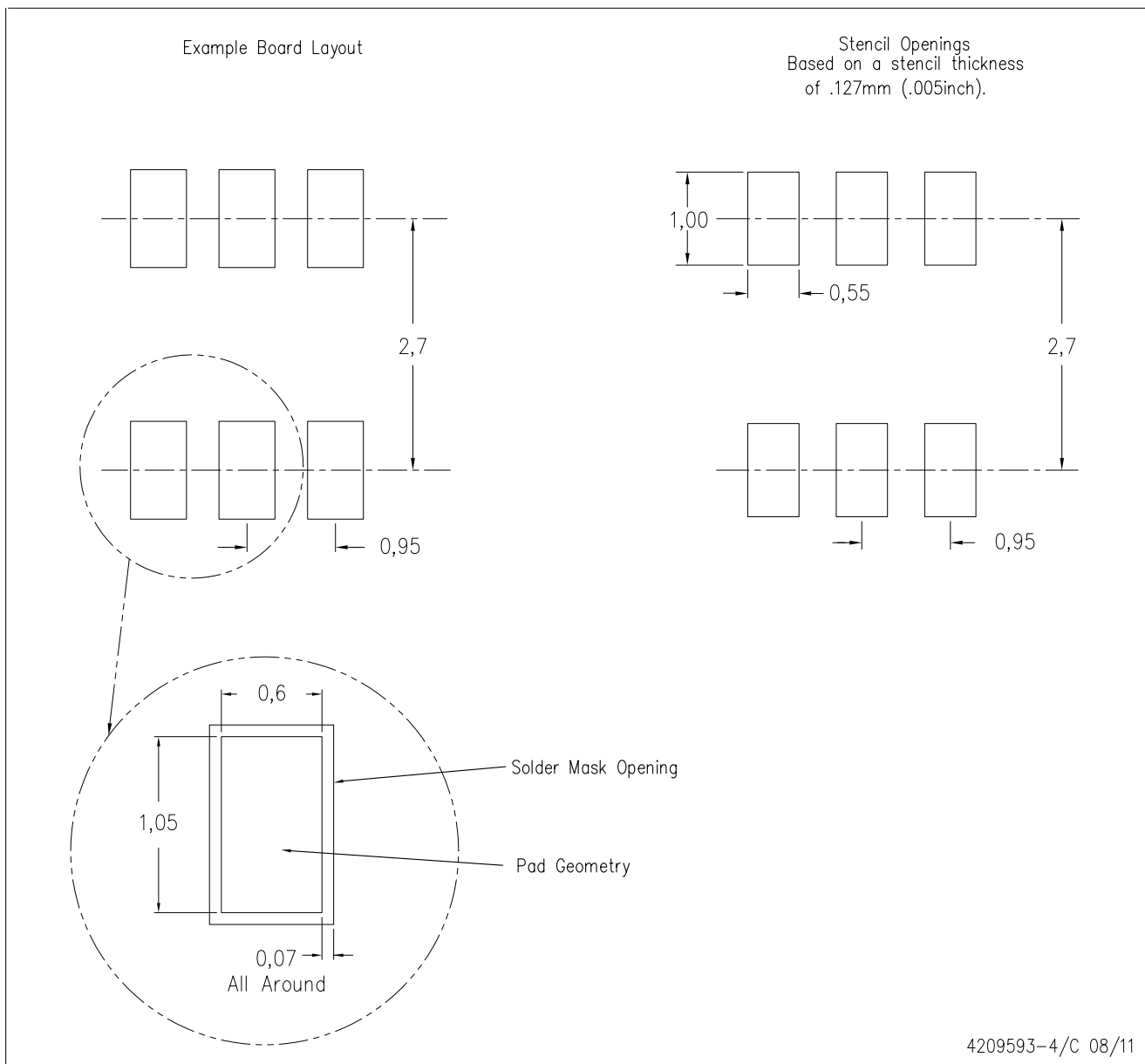
PLASTIC SMALL-OUTLINE PACKAGE



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- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
  - D. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
- $\Delta E$  Falls within JEDEC MO-178 Variation AB, except minimum lead width.

DBV (R-PDSO-G6)

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