



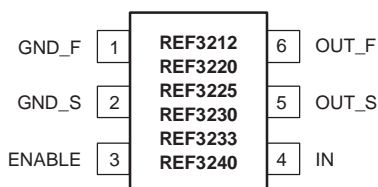
## 4ppm/°C, 100µA, SOT23-6 SERIES VOLTAGE REFERENCE

### FEATURES

- **EXCELLENT SPECIFIED DRIFT PERFORMANCE:**  
7ppm/°C (max) at 0°C to +125°C  
20ppm/°C (max) at –40°C to +125°C
- **MICROSIZE PACKAGE: SOT23-6**
- **HIGH OUTPUT CURRENT: ±10mA**
- **HIGH ACCURACY: 0.01%**
- **LOW QUIESCENT CURRENT: 100µA**
- **LOW DROPOUT: 5mV**

### APPLICATIONS

- **PORTABLE EQUIPMENT**
- **DATA ACQUISITION SYSTEMS**
- **MEDICAL EQUIPMENT**
- **TEST EQUIPMENT**



### 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 (120µA max) of the REF32xx make it ideal for portable and battery-powered applications. This reference is stable with any capacitive load.

The REF32xx can be operated from a supply as low as 5mV above the output voltage, under no load conditions. All models are specified for the wide temperature range of –40°C to +125°C.

### AVAILABLE OUTPUT VOLTAGES

PRODUCT	VOLTAGE
REF3212	1.25V
REF3220	2.048V
REF3225	2.5V
REF3230	3.0V
REF3233	3.3V
REF3240	4.096V



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## ABSOLUTE MAXIMUM RATINGS(1)

Input Voltage .....	+7.5V
Operating Temperature .....	-55°C to +135°C
Storage Temperature .....	-65°C to +150°C
Junction Temperature .....	+150°C
Lead Temperature (soldering, 10s) .....	+300°C
ESD Rating	
Human Body Model .....	4kV
Charged Device Model .....	1kV
Machine Model .....	400V

(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.



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.

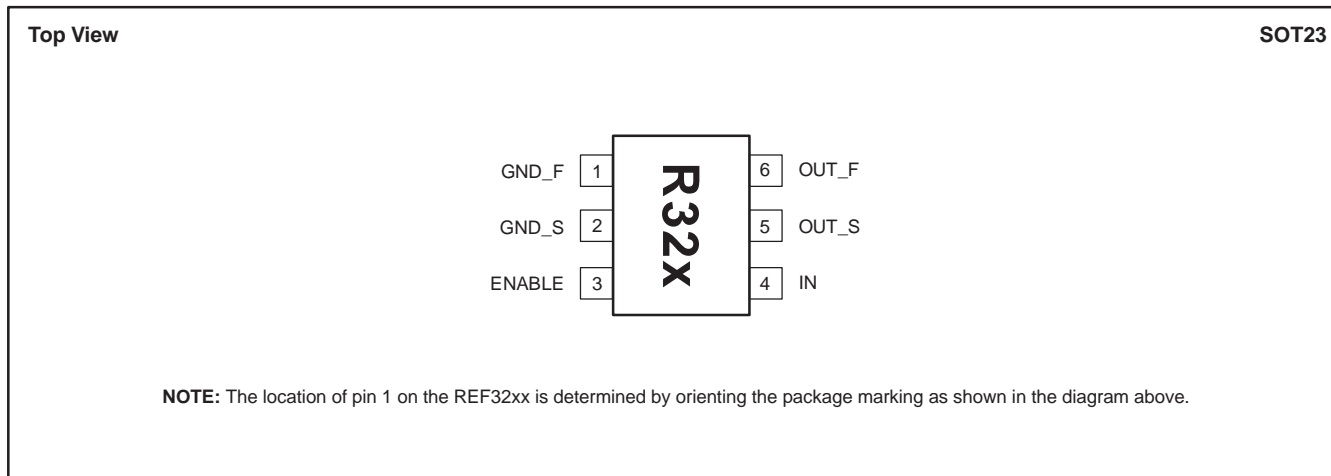
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## PACKAGE/ORDERING INFORMATION(1)

PRODUCT	OUTPUT VOLTAGE	PACKAGE-LEAD	PACKAGE DESIGNATOR	PACKAGE MARKING
REF3212	1.25V	SOT23-6	DBV	R32A
REF3220	2.048V	SOT23-6	DBV	R32B
REF3225	2.5V	SOT23-6	DBV	R32C
REF3230	3.0V	SOT23-6	DBV	R32D
REF3233	3.30V	SOT23-6	DBV	R32E
REF3240	4.096V	SOT23-6	DBV	R32F

(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).

## PIN CONFIGURATION



**ELECTRICAL CHARACTERISTICS**
**Boldface** limits apply over the listed temperature range.

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

PARAMETER	CONDITIONS	REF32xx			UNIT
		MIN	TYP	MAX	
<b>REF3212 (1.25V)</b>					
<b>OUTPUT VOLTAGE, <math>V_{\text{OUT}}</math></b> Initial Accuracy		1.2475 -0.2	1.25 0.01	1.2525 0.2	V %
<b>NOISE</b> Output Voltage Noise Voltage Noise	f = 0.1Hz to 10Hz f = 10Hz to 10kHz		17 24		$\mu\text{V}_{\text{PP}}$ $\mu\text{V}_{\text{RMS}}$
<b>REF3220 (2.048V)</b>					
<b>OUTPUT VOLTAGE, <math>V_{\text{OUT}}</math></b> Initial Accuracy		2.044 -0.2	2.048 0.01	2.052 0.2	V %
<b>NOISE</b> Output Voltage Noise Voltage Noise	f = 0.1Hz to 10Hz f = 10Hz to 10kHz		27 39		$\mu\text{V}_{\text{PP}}$ $\mu\text{V}_{\text{RMS}}$
<b>REF3225 (2.5V)</b>					
<b>OUTPUT VOLTAGE, <math>V_{\text{OUT}}</math></b> Initial Accuracy		2.495 -0.2	2.50 0.01	2.505 0.2	V %
<b>NOISE</b> Output Voltage Noise Voltage Noise	f = 0.1Hz to 10Hz f = 10Hz to 10kHz		33 48		$\mu\text{V}_{\text{PP}}$ $\mu\text{V}_{\text{RMS}}$
<b>REF3230 (3V)</b>					
<b>OUTPUT VOLTAGE, <math>V_{\text{OUT}}</math></b> Initial Accuracy		2.994 -0.2	3 0.01	3.006 0.2	V %
<b>NOISE</b> Output Voltage Noise Voltage Noise	f = 0.1Hz to 10Hz f = 10Hz to 10kHz		39 57		$\mu\text{V}_{\text{PP}}$ $\mu\text{V}_{\text{RMS}}$
<b>REF3233 (3.3V)</b>					
<b>OUTPUT VOLTAGE, <math>V_{\text{OUT}}</math></b> Initial Accuracy		3.293 -0.2	3.3 0.01	3.307 0.2	V %
<b>NOISE</b> Output Voltage Noise Voltage Noise	f = 0.1Hz to 10Hz f = 10Hz to 10kHz		43 63		$\mu\text{V}_{\text{PP}}$ $\mu\text{V}_{\text{RMS}}$
<b>REF3240 (4.096V)</b>					
<b>OUTPUT VOLTAGE, <math>V_{\text{OUT}}</math></b> Initial Accuracy		4.088 -0.2	4.096 0.01	4.104 0.2	V %
<b>NOISE</b> Output Voltage Noise Voltage Noise	f = 0.1Hz to 10Hz f = 10Hz to 10kHz		53 78		$\mu\text{V}_{\text{PP}}$ $\mu\text{V}_{\text{RMS}}$

**ELECTRICAL CHARACTERISTICS (continued)**

**Boldface** limits apply over the listed temperature range.

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

PARAMETER	CONDITIONS	REF32xx			UNIT
		MIN	TYP	MAX	
<b>REF3212 / REF3220 / REF3225 / REF3230 / REF3233 / REF3240</b>					
<b>OUTPUT VOLTAGE TEMP DRIFT</b> $dV_{\text{OUT}}/dT$	$0^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		<b>4</b> 10.5	<b>7</b> 20	ppm/ $^\circ\text{C}$ ppm/ $^\circ\text{C}$
<b>LONG-TERM STABILITY</b>	0 to 1000h		55		ppm
<b>LINE REGULATION</b>	$V_{\text{OUT}} + 0.05^{(1)} \leq V_{\text{IN}} \leq 5.5\text{V}$	-65	15	+65	ppm/V
<b>LOAD REGULATION</b> $dV_{\text{OUT}}/dI_{\text{LOAD}}$	$0\text{mA} < I_{\text{LOAD}} < 10\text{mA}$ , $V_{\text{IN}} = V_{\text{OUT}} + 250\text{mV}^{(1)}$ $-10\text{mA} < I_{\text{LOAD}} < 0\text{mA}$ , $V_{\text{IN}} = V_{\text{OUT}} + 100\text{mV}^{(1)}$	-40 -60	3 20	40 60	$\mu\text{V}/\text{mA}$ $\mu\text{V}/\text{mA}$
<b>THERMAL HYSTERESIS<sup>(2)</sup></b> $dT$			100 25		ppm ppm
<b>DROPOUT VOLTAGE<sup>(1)</sup></b> $V_{\text{IN}} - V_{\text{OUT}}$	$0^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		<b>5</b>	<b>50</b>	<b>mV</b>
<b>OUTPUT CURRENT</b> $I_{\text{LOAD}}$	$V_{\text{IN}} = V_{\text{OUT}} + 250\text{mV}^{(1)}$	-10		10	mA
<b>SHORT-CIRCUIT CURRENT</b> $I_{\text{SC}}$			50 40		mA mA
<b>TURN-ON SETTLING TIME</b>	to 0.1% at $V_{\text{IN}} = 5\text{V}$ with $C_L = 0$		60		$\mu\text{s}$
<b>ENABLE/SHUTDOWN</b> $V_L$ $V_H$	Reference in Shutdown mode Reference is active	0 $0.75 \times V_{\text{IN}}$		0.7 $V_{\text{IN}}$	V V
<b>POWER SUPPLY</b> Voltage Current <b>Over-temperature</b> Shutdown	$I_L = 0$  ENABLE > $0.75 \times V_{\text{IN}}$ $0^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$ ENABLE < 0.7V	$V_{\text{OUT}} + 0.05^{(1)}$	100 <b>115</b> 0.1	5.5 <b>120</b> 1	V $\mu\text{A}$ $\mu\text{A}$ $\mu\text{A}$
<b>TEMPERATURE RANGE</b> Specified Operating Storage Thermal resistance, SOT23-6 $\theta_{\text{JA}}$		-40 -55 -65		+125 +135 +150	$^\circ\text{C}$ $^\circ\text{C}$ $^\circ\text{C}$ $^\circ\text{C}/\text{W}$

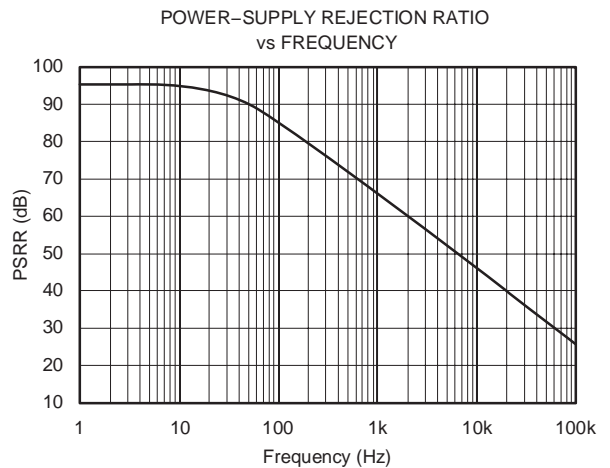
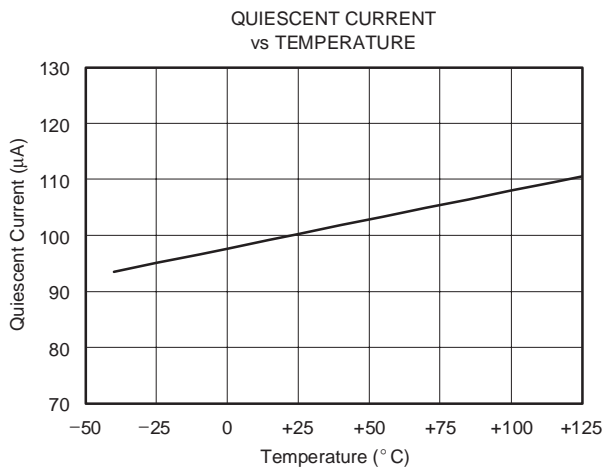
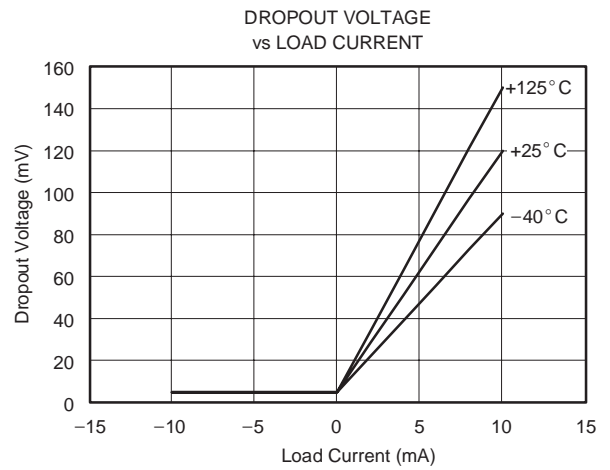
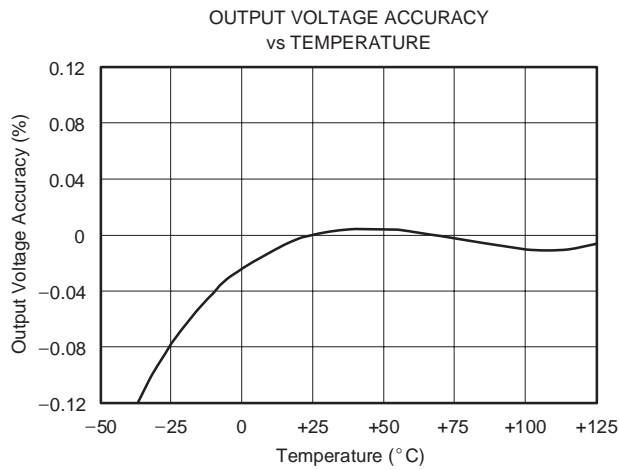
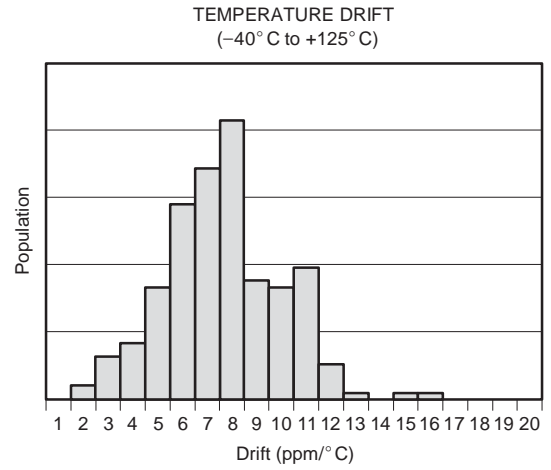
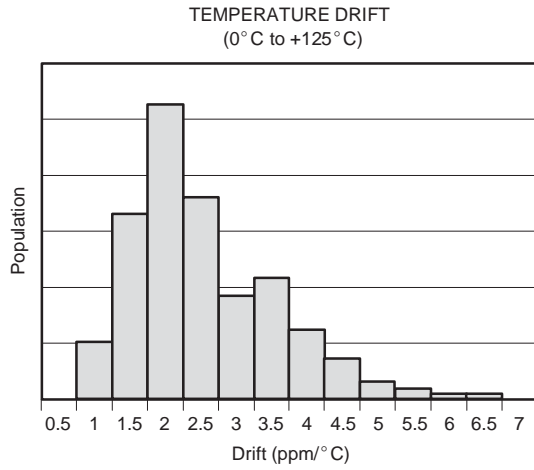
(1) The minimum supply voltage for the REF3212 is 1.8V.

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

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

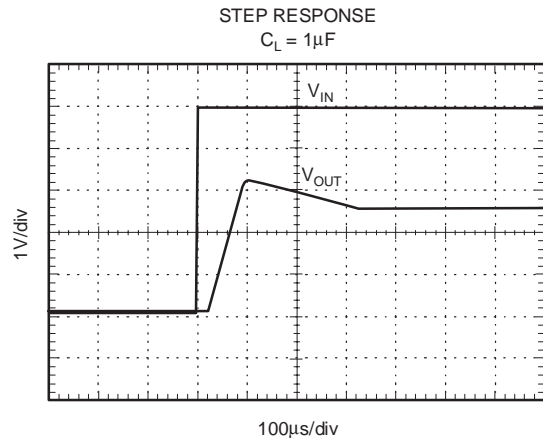
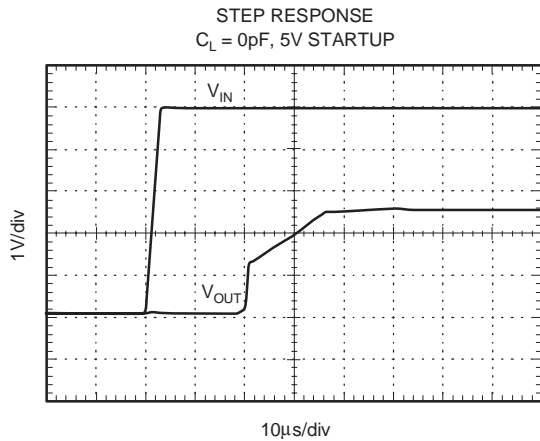
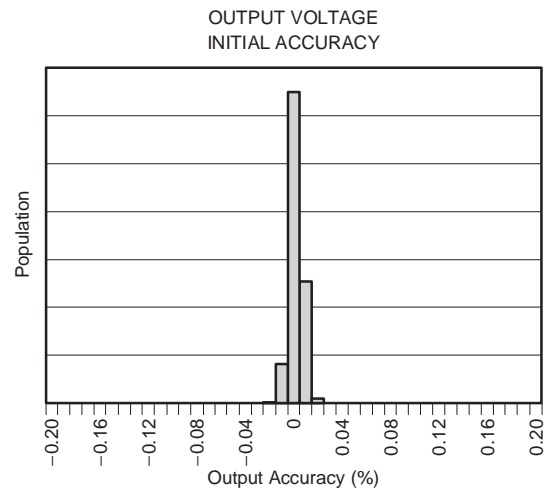
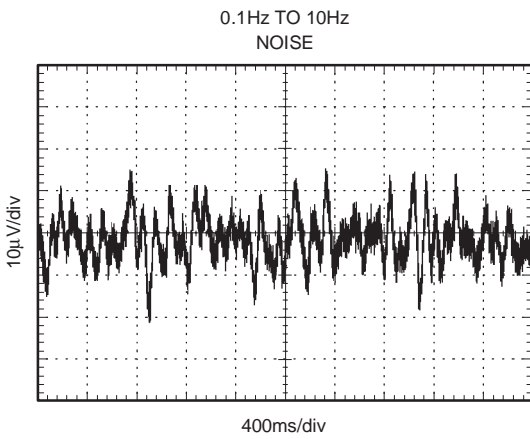
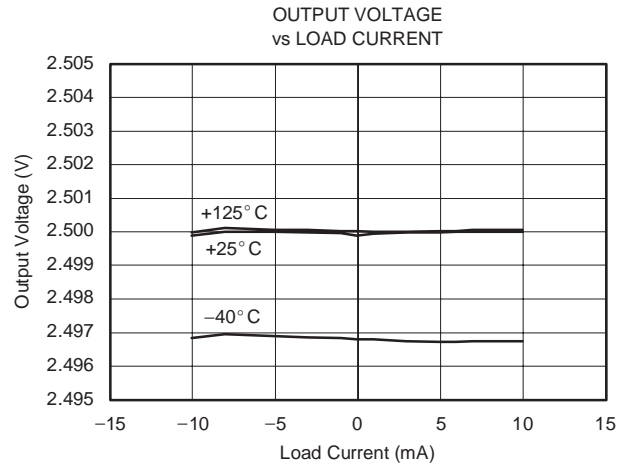
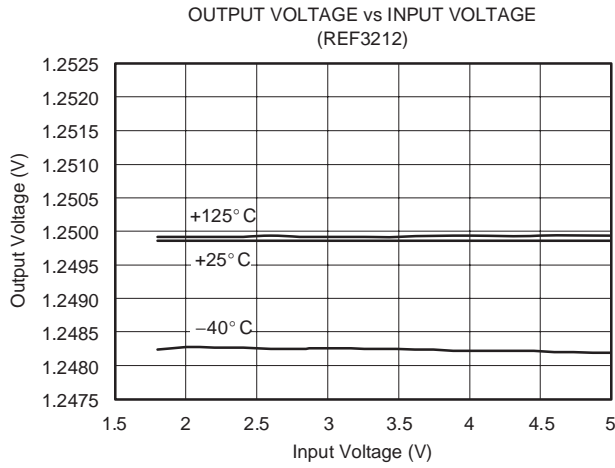
## TYPICAL CHARACTERISTICS

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



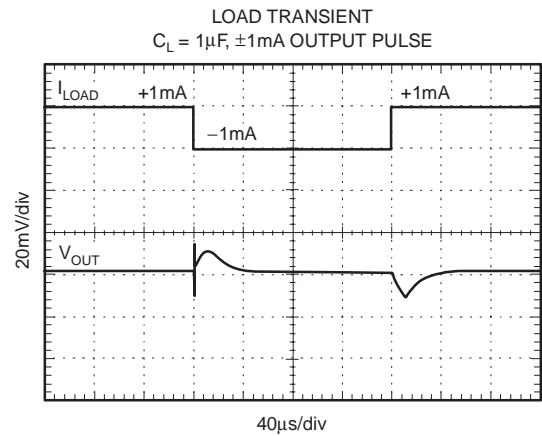
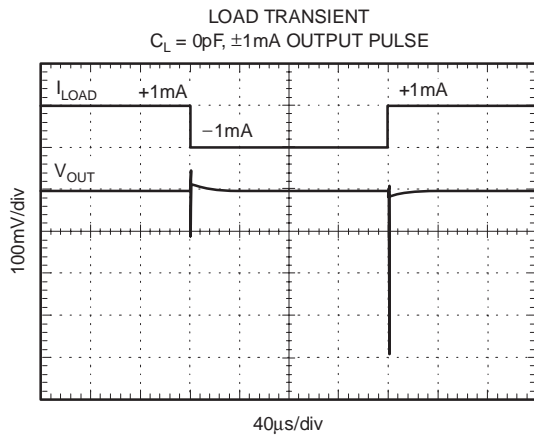
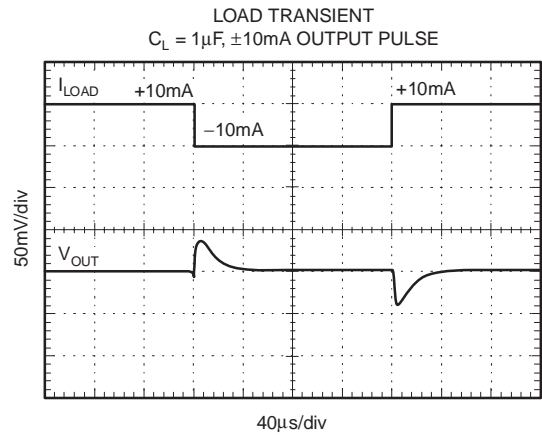
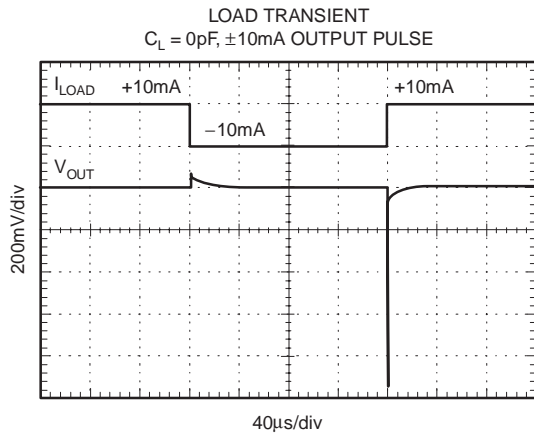
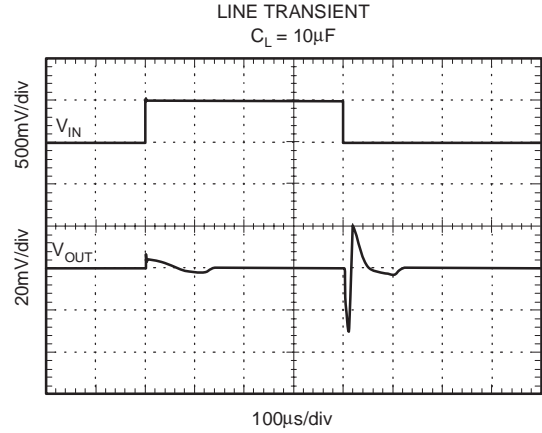
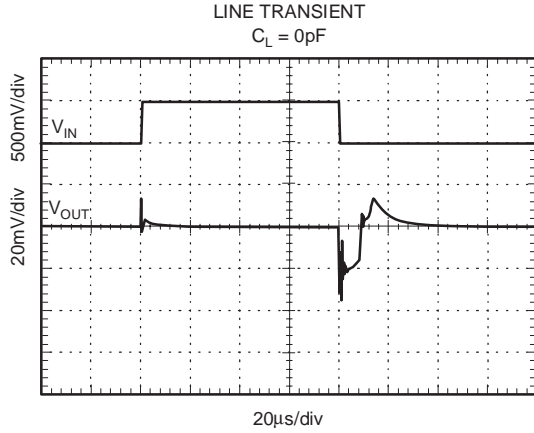
**TYPICAL CHARACTERISTICS (continued)**

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



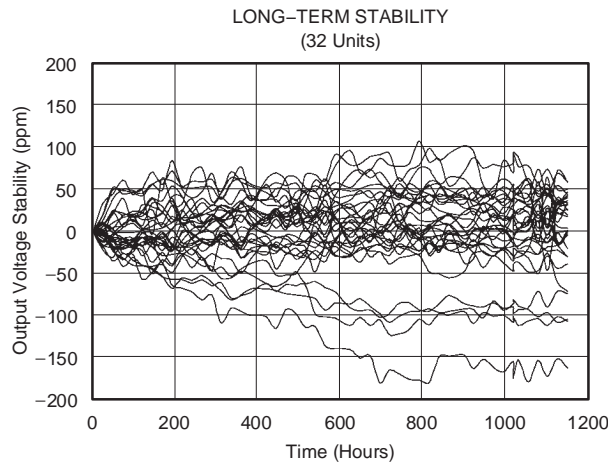
## TYPICAL CHARACTERISTICS (continued)

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



## TYPICAL CHARACTERISTICS (continued)

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



## THEORY OF OPERATION

The REF32xx is a family of CMOS, precision bandgap voltage references. Figure 1 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 ( $V_{be1} - V_{be2}$ ) 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.

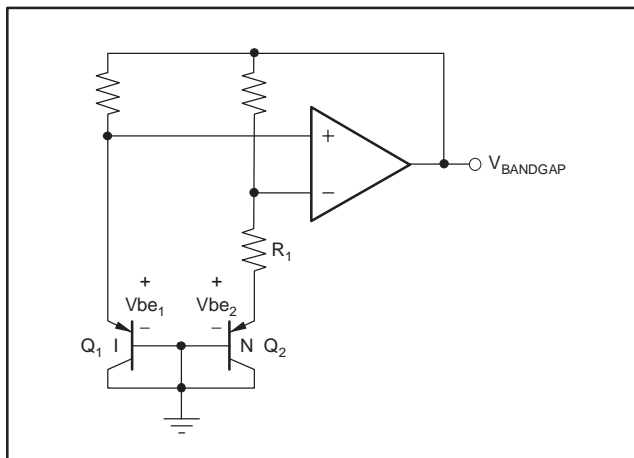


Figure 1. Simplified Schematic of Bandgap Reference

## APPLICATION INFORMATION

The REF32xx does not require a load capacitor and is stable with any capacitive load. Figure 2 shows typical connections required for operation of the REF32xx. A supply bypass capacitor of  $0.47\mu\text{F}$  is recommended.

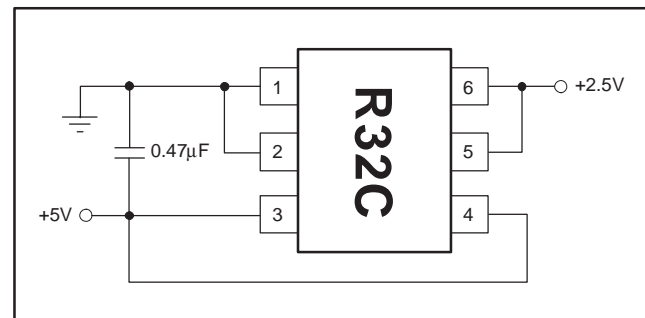


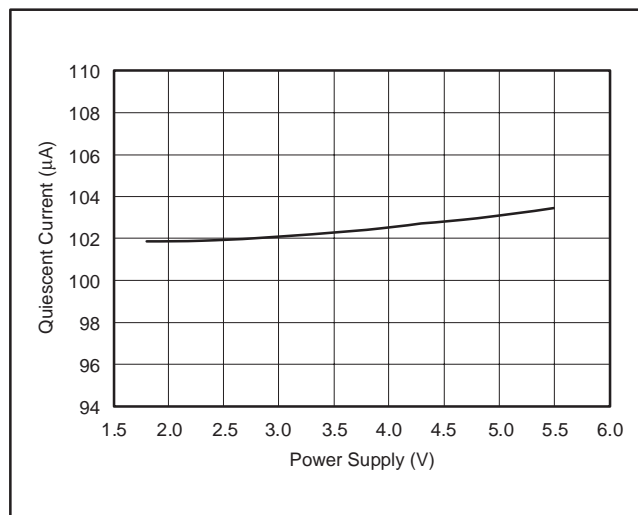
Figure 2. Typical Operating Connections for the REF3225

## 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 1.8V, 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 Characteristic curves.



The REF32xx also features a low quiescent current of 100 $\mu$ A, with a maximum quiescent current over temperature of just 135 $\mu$ A. The quiescent current typically changes less than 2 $\mu$ 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 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.

## 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 100k $\Omega$  to 400k $\Omega$ .

## THERMAL HYSTERESIS

Thermal hysteresis for the REF32xx is defined as the change in output voltage after operating the device at +25 $^{\circ}$ C, cycling the device through the specified temperature range, and returning to +25 $^{\circ}$ 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 $^{\circ}$ C pretemperature cycling.

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

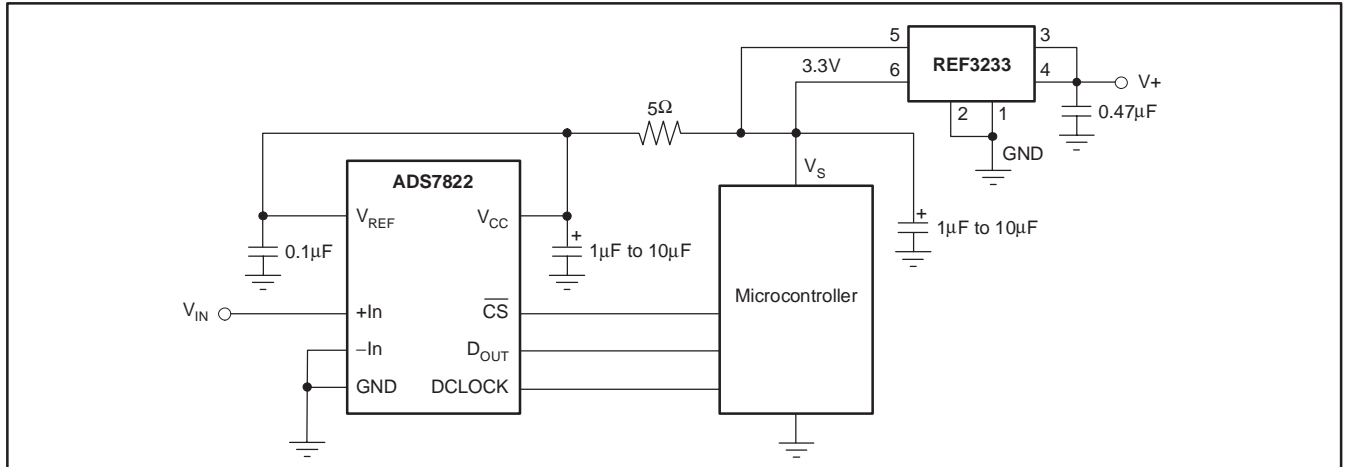
$$\text{Drift} = \left( \frac{V_{\text{OUTMAX}} - V_{\text{OUTMIN}}}{V_{\text{OUT}} \times \text{Temp Range}} \right) \times 10^6 (\text{ppm}) \quad (2)$$

The REF32xx features a typical drift coefficient of 4ppm/ $^{\circ}$ C from 0 $^{\circ}$ C to +125 $^{\circ}$ C—the primary temperature range for many applications. For the extended industrial temperature range of –40 $^{\circ}$ C to +125 $^{\circ}$ C, the REF32xx family drift increases to a typical value of 10.5ppm/ $^{\circ}$ C.

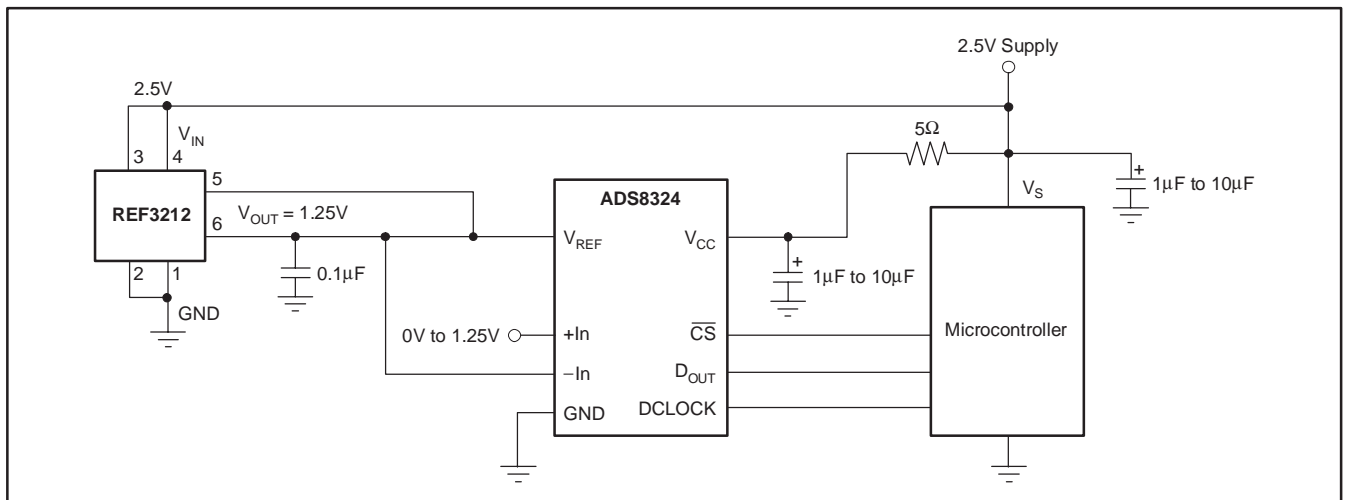
## NOISE PERFORMANCE

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 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.

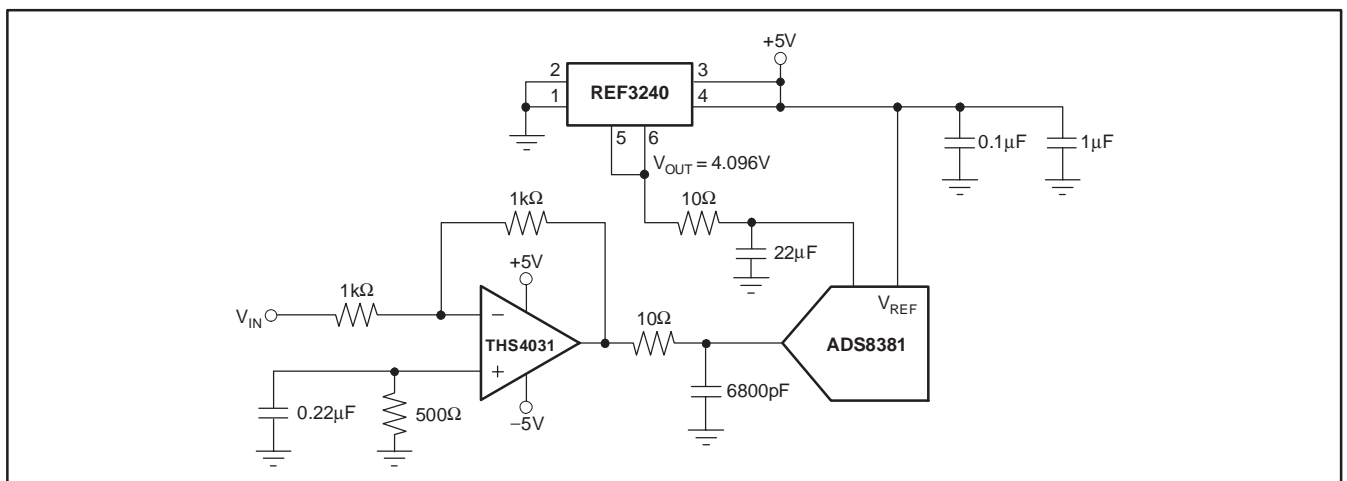




**Figure 6. Basic Data Acquisition System 1**



**Figure 7. Basic Data Acquisition System 2**



**Figure 8. REF3240 Provides an Accurate Reference for Driving the ADS8381**

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
REF3212AIDBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF3212AIDBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF3220AIDBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF3220AIDBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF3225AIDBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF3225AIDBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF3230AIDBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF3230AIDBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF3233AIDBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF3233AIDBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF3240AIDBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF3240AIDBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS) or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

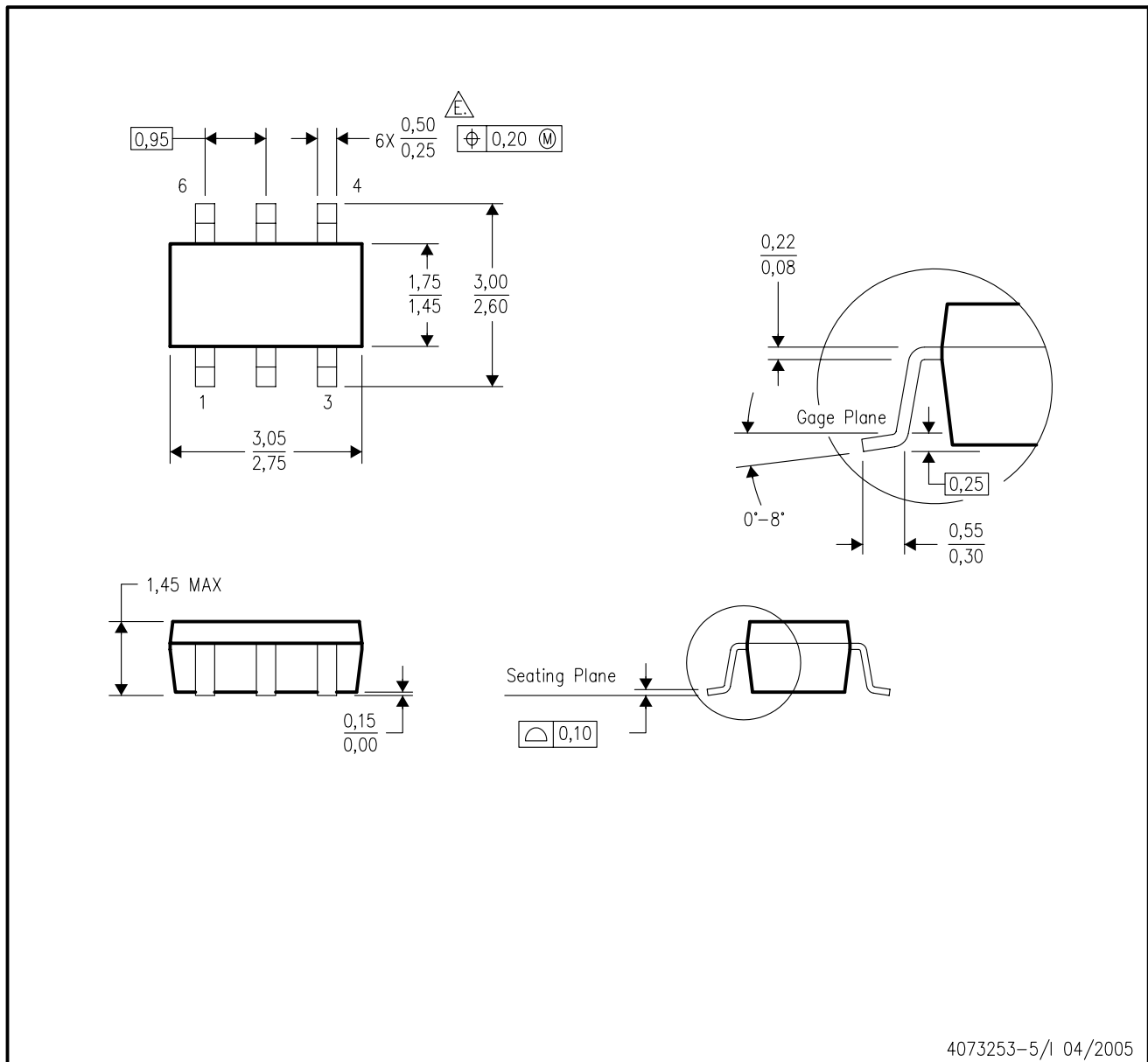
<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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DBV (R-PDSO-G6)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- 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.
  - D. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
- $\triangle$  Falls within JEDEC MO-178 Variation AB, except minimum lead width.

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