

# Low-Noise, Very Low Drift, Precision VOLTAGE REFERENCE

## FEATURES

- **LOW TEMPERATURE DRIFT:**
  - High-Grade: 3ppm/°C (max)
  - Standard-Grade: 8ppm/°C (max)
- **HIGH ACCURACY:**
  - High-Grade: 0.05% (max)
  - Standard-Grade: 0.1% (max)
- **LOW NOISE:** 3 $\mu$ V<sub>PP</sub>/V
- **HIGH OUTPUT CURRENT:**  $\pm$ 10mA
- **TEMPERATURE RANGE:** –40°C to +125°C

## APPLICATIONS

- 16-BIT DATA ACQUISITION SYSTEMS
- ATE EQUIPMENT
- INDUSTRIAL PROCESS CONTROL
- MEDICAL INSTRUMENTATION
- OPTICAL CONTROL SYSTEMS
- PRECISION INSTRUMENTATION

## DESCRIPTION

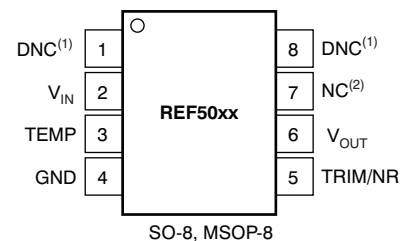
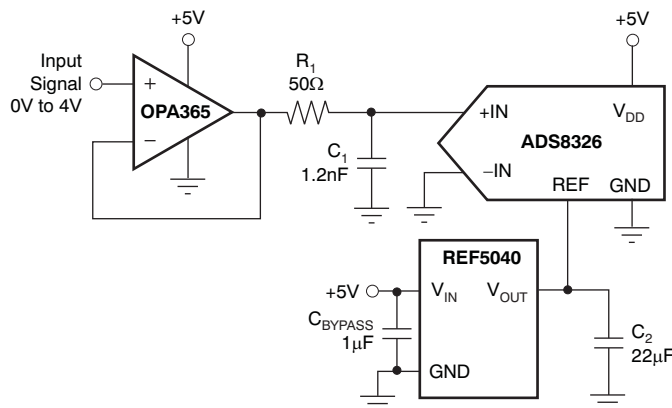
The REF50xx is a family of low-noise, low-drift, very high precision voltage references. These references are capable of both sinking and sourcing, and are very robust with regard to line and load changes.

Excellent temperature drift (3ppm/°C) and high accuracy (0.05%) are achieved using proprietary design techniques. These features, combined with very-low noise make the REF50xx family ideal for use in high-precision data acquisition systems.

Each reference voltage is available in both standard- and high-grade versions. They are offered in MSOP-8 and SO-8 packages, and are specified from –40°C to +125°C.

**REF50xx Family**

MODEL	OUTPUT VOLTAGE
REF5020	2.048V
REF5025	2.5V
REF5030	3.0V
REF5040	4.096V
REF5045	4.5V
REF5050	5.0V
REF5010	10.0V



NOTES: (1) DNC = Do not connect.  
(2) NC = No internal connection.



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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<sup>(1)</sup>

PRODUCT	OUTPUT VOLTAGE	PACKAGE-LEAD	PACKAGE DESIGNATOR	PACKAGE MARKING
<b>STANDARD GRADE (8ppm, 0.1%)</b>				
REF5020AI	2.048V	SO-8	D	REF5020
		MSOP-8	DGK	R50A
REF5025AI	2.5V	SO-8	D	REF5025
		MSOP-8	DGK	R50B
REF5030AI	3.0V	SO-8	D	REF5030
		MSOP-8	DGK	R50C
REF5040AI	4.096V	SO-8	D	REF5040
		MSOP-8	DGK	R50D
REF5045AI	4.5V	SO-8	D	REF5045
		MSOP-8	DGK	R50E
REF5050AI	5.0V	SO-8	D	REF5050
		MSOP-8	DGK	R50F
REF5010AI	10.0V	SO-8	D	REF5010
		MSOP-8	DGK	R50G
<b>HIGH GRADE (3ppm, 0.05%)</b>				
REF5020I	2.048V	SO-8	D	REF5020
		MSOP-8	DGK	R50A
REF5025I	2.5V	SO-8	D	REF5025
		MSOP-8	DGK	R50B
REF5030I	3.0V	SO-8	D	REF5030
		MSOP-8	DGK	R50C
REF5040I	4.096V	SO-8	D	REF5040
		MSOP-8	DGK	R50D
REF5045I	4.5V	SO-8	D	REF5045
		MSOP-8	DGK	R50E
REF5050I	5.0V	SO-8	D	REF5050
		MSOP-8	DGK	R50F
REF5010I	10.0V	SO-8	D	REF5010
		MSOP-8	DGK	R50G

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

### ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

PARAMETER	REF50xx	UNIT
Input Voltage	+18	V
Output Short-Circuit	30	mA
Operating Temperature Range	–55 to +125	°C
Storage Temperature Range	–65 to +150	°C
Junction Temperature (T <sub>J</sub> max)	+150	°C
ESD Rating	Human Body Model (HBM)	3000
	Charged Device Model (CDM)	1000

(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.

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

 At  $T_A = +25^{\circ}\text{C}$ ,  $I_{\text{LOAD}} = 0$ ,  $C_L = 1\mu\text{F}$ , and  $V_{\text{IN}} = (V_{\text{OUT}} + 0.2\text{V})$  to 18V, unless otherwise noted.

PARAMETER	CONDITIONS	PER DEVICE			UNIT
		MIN	TYP	MAX	
<b>REF5020 (<math>V_{\text{OUT}} = 2.048\text{V}</math>)<sup>(1)</sup></b>					
<b>OUTPUT VOLTAGE</b>					
Output Voltage	$V_{\text{OUT}}$ $2.7\text{V} < V_{\text{IN}} < 18\text{V}$		2.048		V
Initial Accuracy:					
High-Grade		-0.05		0.05	%
Standard-Grade		-0.1		0.1	%
<b>NOISE</b>					
Output Voltage Noise	$f = 0.1\text{Hz}$ to 10Hz		6		$\mu\text{V}_{\text{PP}}$
<b>REF5025 (<math>V_{\text{OUT}} = 2.5\text{V}</math>)</b>					
<b>OUTPUT VOLTAGE</b>					
Output Voltage	$V_{\text{OUT}}$		2.5		V
Initial Accuracy:					
High-Grade		-0.05		0.05	%
Standard-Grade		-0.1		0.1	%
<b>NOISE</b>					
Output Voltage Noise	$f = 0.1\text{Hz}$ to 10Hz		7.5		$\mu\text{V}_{\text{PP}}$
<b>REF5030 (<math>V_{\text{OUT}} = 3.0\text{V}</math>)</b>					
<b>OUTPUT VOLTAGE</b>					
Output Voltage	$V_{\text{OUT}}$		3.0		V
Initial Accuracy:					
High-Grade		-0.05		0.05	%
Standard-Grade		-0.1		0.1	%
<b>NOISE</b>					
Output Voltage Noise	$f = 0.1\text{Hz}$ to 10Hz		9		$\mu\text{V}_{\text{PP}}$
<b>REF5040 (<math>V_{\text{OUT}} = 4.096\text{V}</math>)</b>					
<b>OUTPUT VOLTAGE</b>					
Output Voltage	$V_{\text{OUT}}$		4.096		V
Initial Accuracy:					
High-Grade		-0.05		0.05	%
Standard-Grade		-0.1		0.1	%
<b>NOISE</b>					
Output Voltage Noise	$f = 0.1\text{Hz}$ to 10Hz		12		$\mu\text{V}_{\text{PP}}$
<b>REF5045 (<math>V_{\text{OUT}} = 4.5\text{V}</math>)</b>					
<b>OUTPUT VOLTAGE</b>					
Output Voltage	$V_{\text{OUT}}$		4.5		V
Initial Accuracy:					
High-Grade		-0.05		0.05	%
Standard-Grade		-0.1		0.1	%
<b>NOISE</b>					
Output Voltage Noise	$f = 0.1\text{Hz}$ to 10Hz		13.5		$\mu\text{V}_{\text{PP}}$
<b>REF5050 (<math>V_{\text{OUT}} = 5.0\text{V}</math>)</b>					
<b>OUTPUT VOLTAGE</b>					
Output Voltage	$V_{\text{OUT}}$		5.0		V
Initial Accuracy:					
High-Grade		-0.05		0.05	%
Standard-Grade		-0.1		0.1	%
<b>NOISE</b>					
Output Voltage Noise	$f = 0.1\text{Hz}$ to 10Hz		15		$\mu\text{V}_{\text{PP}}$
<b>REF5010 (<math>V_{\text{OUT}} = 10.0\text{V}</math>)</b>					
<b>OUTPUT VOLTAGE</b>					
Output Voltage	$V_{\text{OUT}}$		10.0		V
Initial Accuracy:					
High-Grade		-0.05		0.05	%
Standard-Grade		-0.1		0.1	%
<b>NOISE</b>					
Output Voltage Noise	$f = 0.1\text{Hz}$ to 10Hz		30		$\mu\text{V}_{\text{PP}}$

 (1) For  $V_{\text{OUT}} \leq 2.5\text{V}$ , the minimum supply voltage is 2.7V.

## ELECTRICAL CHARACTERISTICS: ALL DEVICES

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

At  $T_A = +25^{\circ}\text{C}$ ,  $I_{\text{LOAD}} = 0$ ,  $C_L = 1\mu\text{F}$ , and  $V_{\text{IN}} = (V_{\text{OUT}} + 0.2\text{V})$  to 18V, unless otherwise noted.

PARAMETER	CONDITIONS	REF50xx			UNIT
		MIN	TYP	MAX	
<b>OUTPUT VOLTAGE TEMPERATURE DRIFT</b>					
Output Voltage Temperature Drift	$dV_{\text{OUT}}/dT$				
High-Grade			2.5	3	ppm/ $^{\circ}\text{C}$
Standard-Grade			3	8	ppm/ $^{\circ}\text{C}$
<b>LINE REGULATION</b>					
Line Regulation	$dV_{\text{OUT}}/dV_{\text{IN}}$				
REF5020 <sup>(1)</sup> Only	$V_{\text{IN}} = 2.7\text{V}$ to 18V		0.1	1	ppm/V
All Other Devices	$V_{\text{IN}} = V_{\text{OUT}} + 0.2\text{V}$		0.1	1	ppm/V
<b>Over Temperature</b>			<b>0.2</b>	<b>1</b>	<b>ppm/V</b>
<b>LOAD REGULATION</b>					
Load Regulation	$dV_{\text{OUT}}/dI_{\text{LOAD}}$				
REF5020 Only	$-10\text{mA} < I_{\text{LOAD}} < +10\text{mA}$ $V_{\text{IN}} = 3\text{V}$		20	30	ppm/mA
All Other Devices	$V_{\text{IN}} = V_{\text{OUT}} + 0.75\text{V}$		20	30	ppm/mA
<b>Over Temperature</b>				<b>50</b>	<b>ppm/mA</b>
<b>SHORT-CIRCUIT CURRENT</b>					
Short-Circuit Current	$I_{\text{SC}}$	$V_{\text{OUT}} = 0$		25	mA
<b>TEMP PIN</b>					
Voltage Output		At $T_A = +25^{\circ}\text{C}$		575	mV
Temperature Sensitivity				<b>2.64</b>	<b>mV/<math>^{\circ}\text{C}</math></b>
<b>TURN-ON SETTLING TIME</b>					
Turn-On Settling Time		To 0.1% with $C_L = 1\mu\text{F}$		200	$\mu\text{s}$
<b>POWER SUPPLY</b>					
Supply Voltage	$V_S$	See Note <sup>(1)</sup>	$V_{\text{OUT}} + 0.2^{(1)}$	18	V
Quiescent Current			0.8	1	mA
<b>Over Temperature</b>				<b>1.2</b>	<b>mA</b>
<b>TEMPERATURE RANGE</b>					
Specified Range			-40	+125	$^{\circ}\text{C}$
Operating Range			-55	+125	$^{\circ}\text{C}$
Thermal Resistance	$\theta_{\text{JA}}$				
MSOP-8			150		$^{\circ}\text{C}/\text{W}$
SO-8			150		$^{\circ}\text{C}/\text{W}$

(1) For  $V_{\text{OUT}} \leq 2.5\text{V}$ , the minimal supply voltage is 2.7V.

TYPICAL CHARACTERISTICS

At  $T_A = +25^\circ\text{C}$ ,  $I_{\text{LOAD}} = 0$ , and  $V_S = V_{\text{OUT}} + 0.2\text{V}$ , unless otherwise noted. For  $V_{\text{OUT}} \leq 2.5\text{V}$ , the minimum supply voltage is 2.7V.

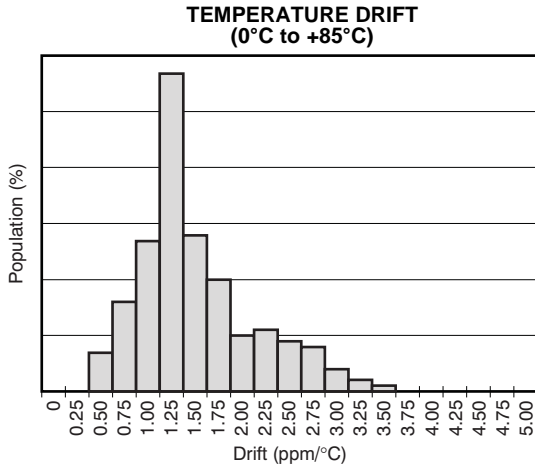


Figure 1.

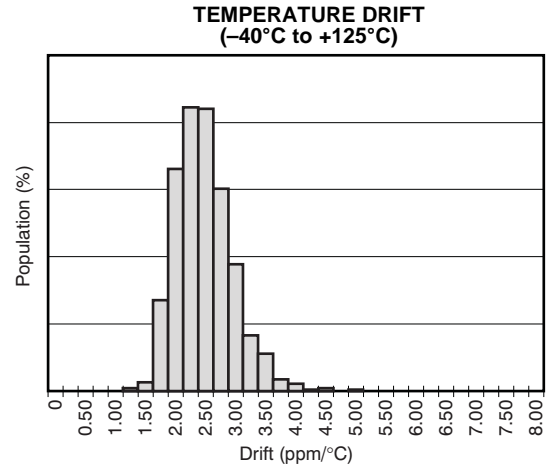


Figure 2.

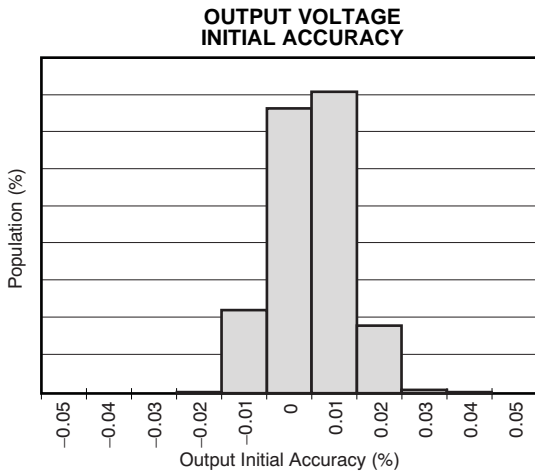


Figure 3.

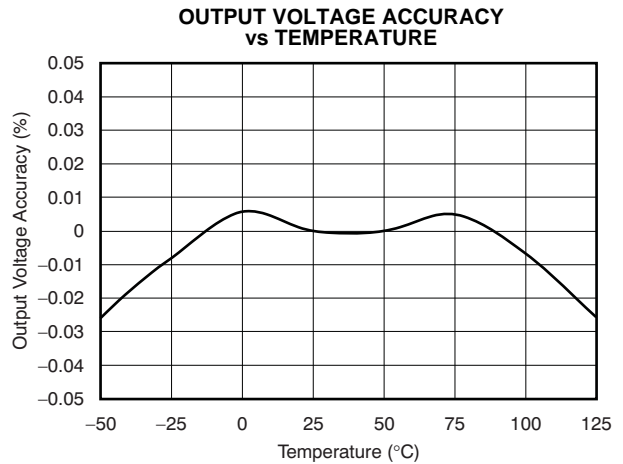


Figure 4.

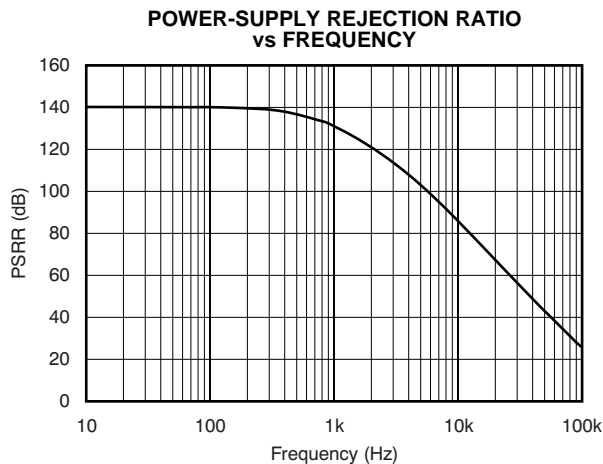


Figure 5.

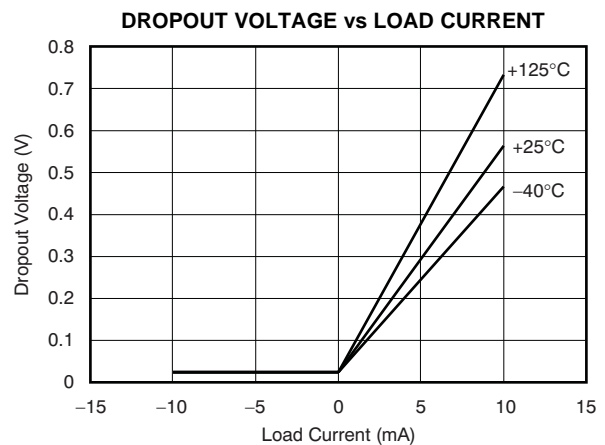


Figure 6.

TYPICAL CHARACTERISTICS (continued)

At  $T_A = +25^\circ\text{C}$ ,  $I_{\text{LOAD}} = 0$ , and  $V_S = V_{\text{OUT}} + 0.2\text{V}$ , unless otherwise noted. For  $V_{\text{OUT}} \leq 2.5\text{V}$ , the minimum supply voltage is 2.7V.

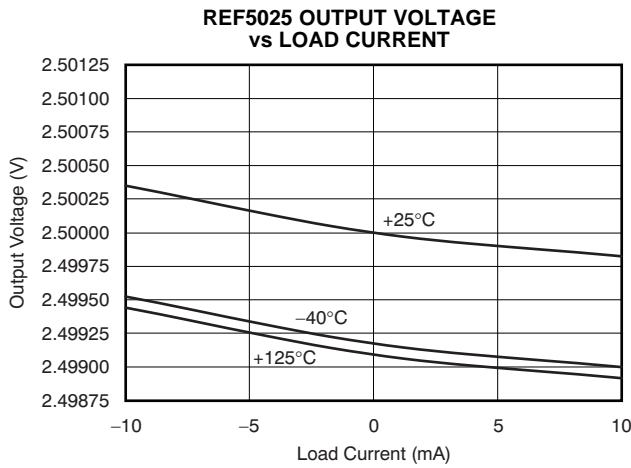


Figure 7.

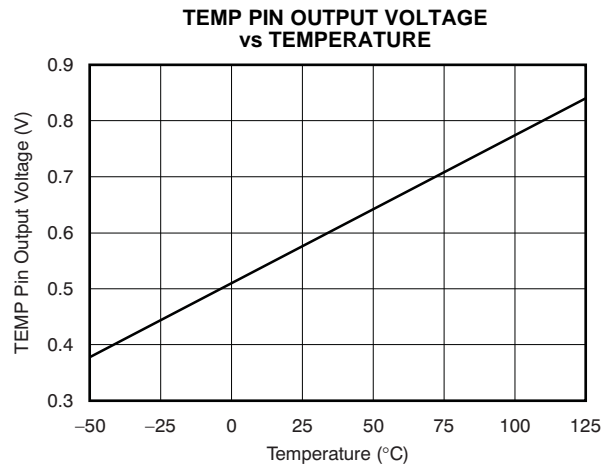


Figure 8.

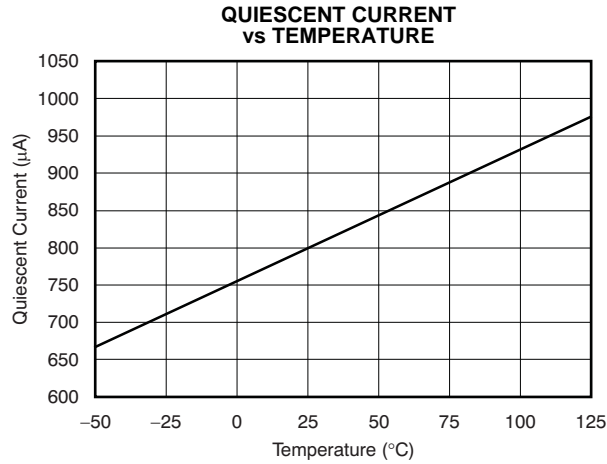


Figure 9.

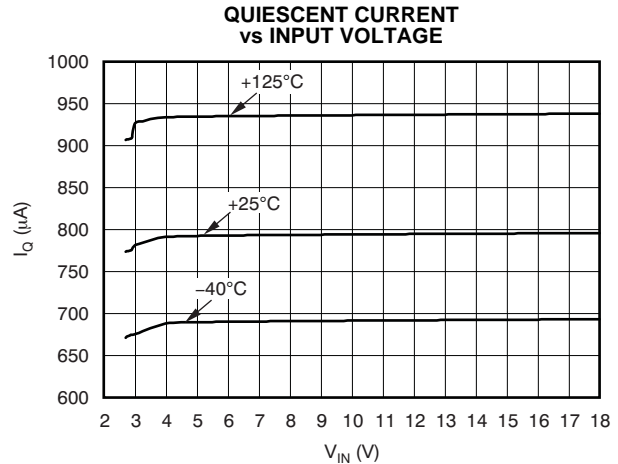


Figure 10.

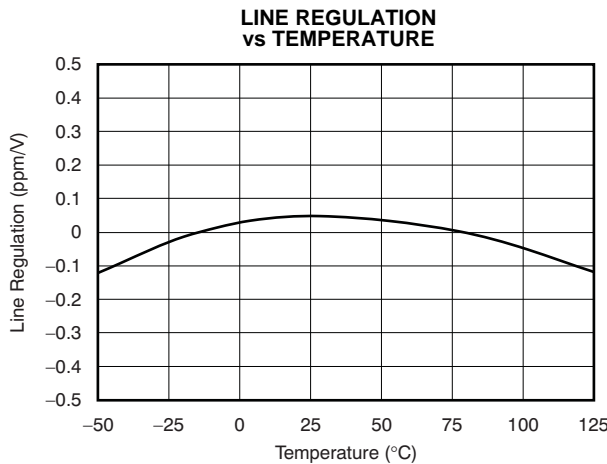


Figure 11.

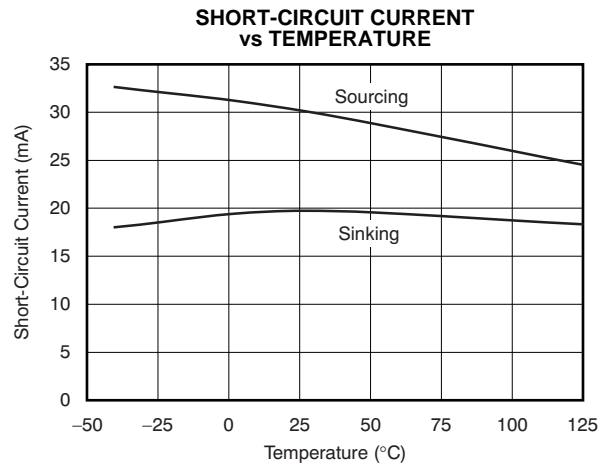
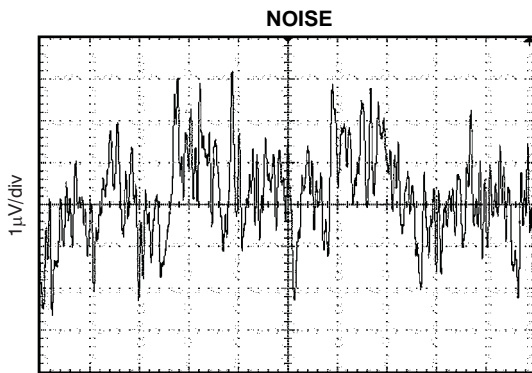


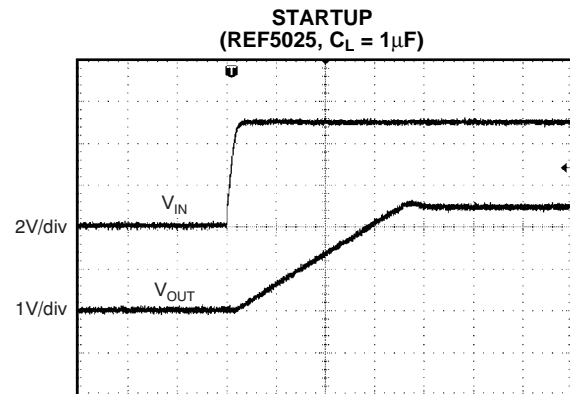
Figure 12.

TYPICAL CHARACTERISTICS (continued)

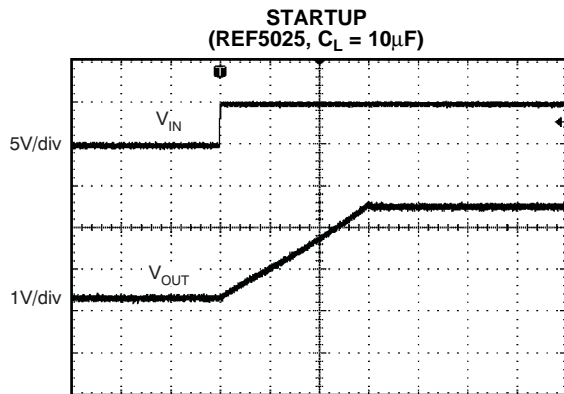
At  $T_A = +25^\circ\text{C}$ ,  $I_{\text{LOAD}} = 0$ , and  $V_S = V_{\text{OUT}} + 0.2\text{V}$ , unless otherwise noted. For  $V_{\text{OUT}} \leq 2.5\text{V}$ , the minimum supply voltage is 2.7V.



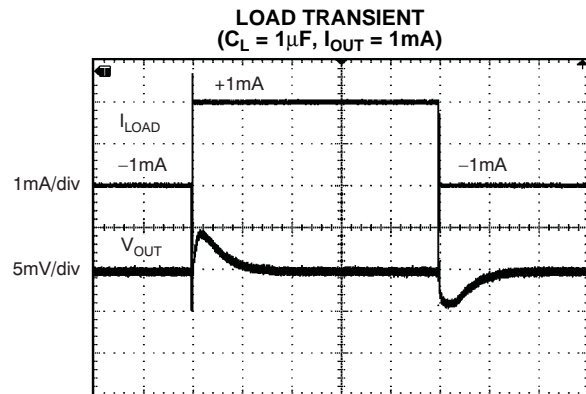
1s/div  
Figure 13.



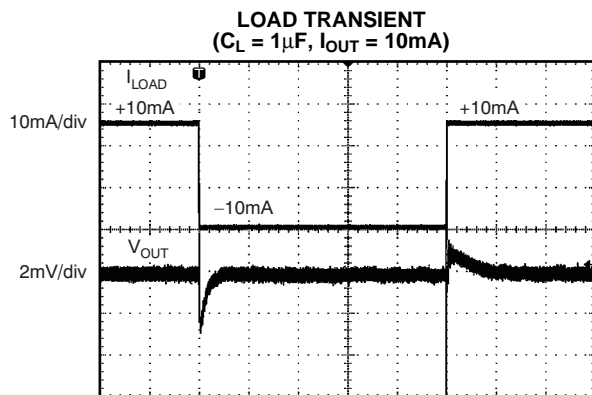
40µs/div  
Figure 14.



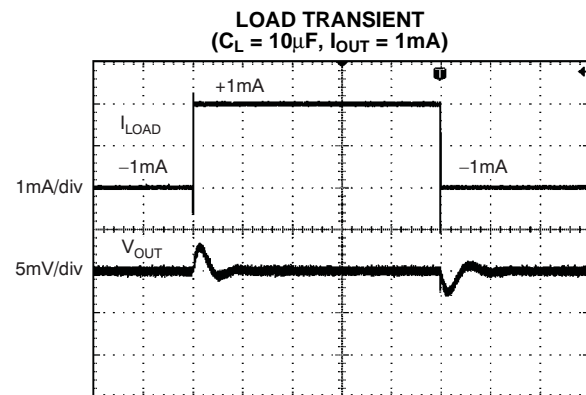
400µs/div  
Figure 15.



20µs/div  
Figure 16.



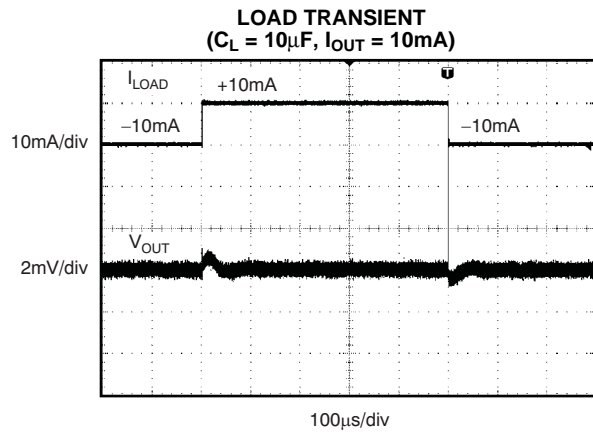
20µs/div  
Figure 17.



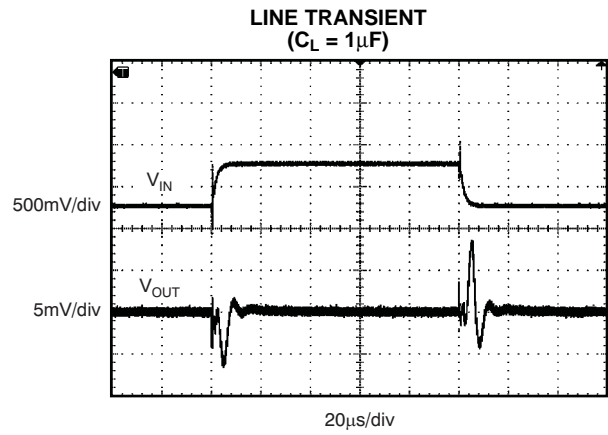
100µs/div  
Figure 18.

**TYPICAL CHARACTERISTICS (continued)**

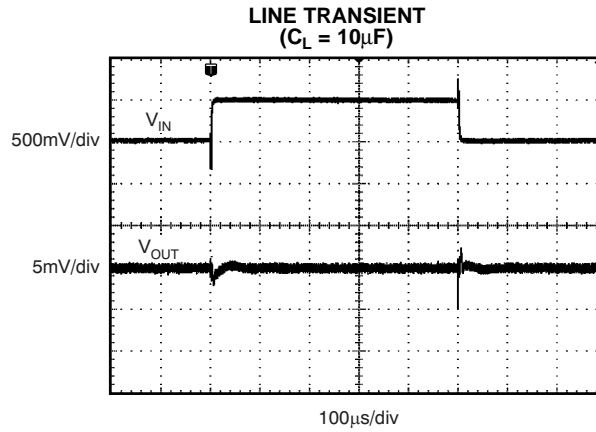
At  $T_A = +25^\circ\text{C}$ ,  $I_{\text{LOAD}} = 0$ , and  $V_S = V_{\text{OUT}} + 0.2\text{V}$ , unless otherwise noted. For  $V_{\text{OUT}} \leq 2.5\text{V}$ , the minimum supply voltage is 2.7V.



**Figure 19.**



**Figure 20.**



**Figure 21.**



## APPLICATION INFORMATION

The REF50xx is family of low-noise, precision bandgap voltage references that are specifically designed for excellent initial voltage accuracy and drift. Figure 22 shows a simplified block diagram of the REF50xx.

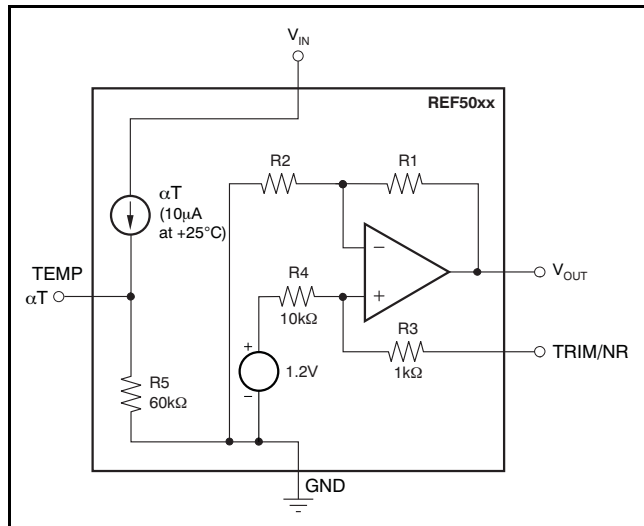


Figure 22. REF50xx Simplified Block Diagram

### BASIC CONNECTIONS

Figure 23 shows the typical connections for the REF50xx. A supply bypass capacitor ranging between  $1\mu\text{F}$  to  $10\mu\text{F}$  is recommended. A  $1\mu\text{F}$  to  $50\mu\text{F}$  output capacitor ( $C_L$ ) must be connected from  $V_{\text{OUT}}$  to GND. The ESR value of  $C_L$  must be less than or equal to  $1.5\Omega$  to ensure output stability. To minimize noise, the recommended ESR of  $C_L$  is between  $1\Omega$  and  $1.5\Omega$ .

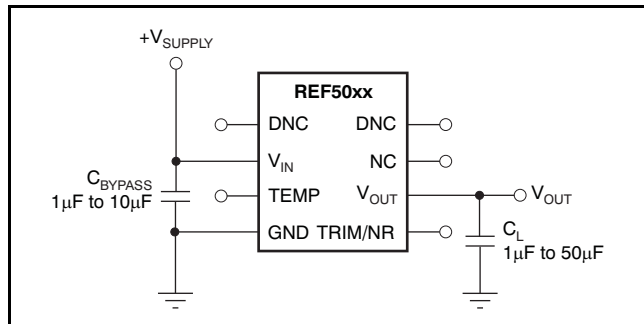


Figure 23. Basic Connections

### SUPPLY VOLTAGE

The REF50xx family of voltage references features extremely low dropout voltage. With the exception of the REF5020, which has a minimum supply

requirement of 2.7V, these references can be operated with a supply of 200mV above the output voltage in an unloaded condition. For loaded conditions, a typical dropout voltage versus load plot is shown in Figure 6 of the Typical Characteristics.

### OUTPUT ADJUSTMENT USING THE TRIM/NR PIN

The REF50xx provides a very accurate, factory-trimmed voltage output. However,  $V_{\text{OUT}}$  can be adjusted using the trim and noise reduction pin (TRIM/NR, pin 5). Figure 24 shows a typical circuit that allows an output adjustment of  $\pm 15\text{mV}$

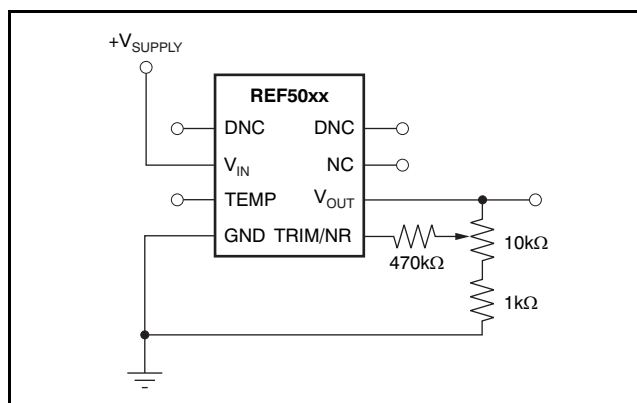


Figure 24.  $V_{\text{OUT}}$  Adjustment Using the TRIM/NR Pin

The REF50xx allows access to the bandgap through the TRIM/NR pin. Placing a capacitor from the TRIM/NR pin to GND (as Figure 25 illustrates) in combination with the internal  $R_3$  and  $R_4$  resistors creates a low-pass filter. A capacitance of  $1\mu\text{F}$  creates a low-pass filter with the corner frequency between 10Hz and 20Hz. Such a filter decreases the overall noise measured on the  $V_{\text{OUT}}$  pin by half. Higher capacitance results in a lower filter cutoff frequency, further reducing output noise. Note that use of this capacitor increases startup time.

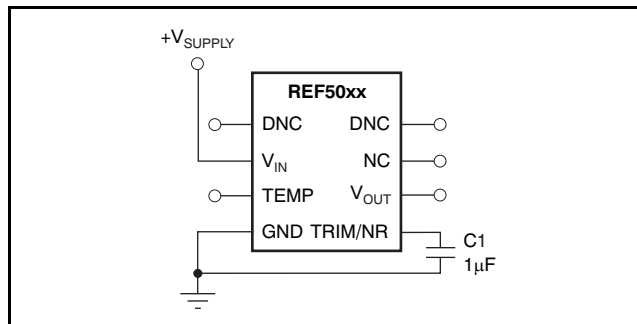


Figure 25. Noise Reduction Using the TRIM/NR Pin

## TEMPERATURE DRIFT

The REF50xx is designed for minimal drift error, which is defined as the change in output voltage over temperature. The drift is calculated using the box method, as described by the following equation:

$$\text{Drift} = \left( \frac{V_{\text{OUTMAX}} - V_{\text{OUTMIN}}}{V_{\text{OUT}} \times \text{Temp Range}} \right) \times 10^6 (\text{ppm}) \quad (1)$$

The REF50xx features a maximum drift coefficient of 3ppm/°C for the high-grade version, and 8ppm/°C for the standard-grade.

## TEMPERATURE MONITORING

The temperature output terminal (TEMP, pin 3) provides a temperature-dependent voltage output with approximately 60kΩ source impedance. As seen in [Figure 8](#), the output voltage follows the nominal relationship:

$$V_{\text{TEMP PIN}} = 509\text{mV} + 2.64 \times T(^{\circ}\text{C})$$

This pin indicates general chip temperature, accurate to approximately ±15°C. Although it is not generally suitable for accurate temperature measurements, it can be used to indicate temperature changes or for temperature compensation of analog circuitry. A temperature change of 30°C corresponds to an approximate 79mV change in voltage at the TEMP pin.

The TEMP pin has high output impedance (see [Figure 22](#)). Loading this pin with a low-impedance circuit induces a measurement error; however, it does not have any effect on  $V_{\text{OUT}}$  accuracy. To avoid errors caused by low-impedance loading, buffer the TEMP pin output with a suitable low-temperature drift op amp, such as the [OPA333](#), [OPA335](#), or [OPA376](#), as shown in [Figure 26](#).

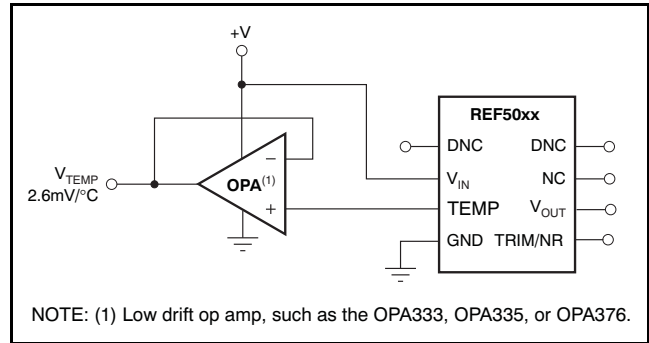


Figure 26. Buffering the TEMP Pin Output

## POWER DISSIPATION

The REF50xx family is specified to deliver current loads of ±10mA over the specified input voltage range. The temperature of the device increases according to the equation:

$$T_J = T_A + P_D \times \theta_{JA}$$

Where:

$T_J$  = Junction temperature (°C)

$T_A$  = Ambient temperature (°C)

$P_D$  = Power dissipated (W)

$\theta_{JA}$  = Junction-to-ambient thermal resistance (°C/W)

The REF50xx junction temperature must not exceed the absolute maximum rating of +150°C.

## NOISE PERFORMANCE

Typical 0.1Hz to 10Hz voltage noise for each member of the REF50xx family is specified in the [Electrical Characteristics: Per Device](#) table. The noise voltage 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 performance.

## APPLICATION CIRCUITS

### NEGATIVE REFERENCE VOLTAGE

For applications requiring a negative and positive reference voltage, the REF50xx and OPA735 can be used to provide a dual-supply reference from a 5V supply. Figure 27 shows the REF5025 used to provide a 2.5V supply reference voltage. The low drift performance of the REF50xx 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  $R_2$ .

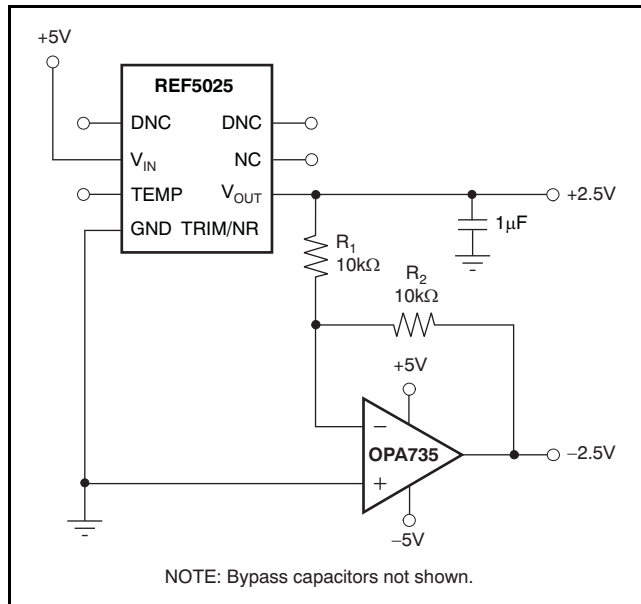


Figure 27. The REF5025 and OPA735 Create Positive and Negative Reference Voltages

### DATA ACQUISITION

Data acquisition systems often require stable voltage references to maintain accuracy. The REF50xx family features low noise, very low drift, and high initial accuracy for high-performance data converters. Figure 28 shows the REF5040 in a basic data acquisition system.

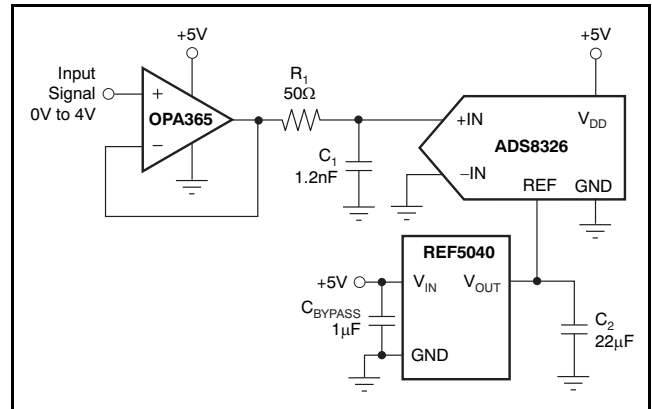


Figure 28. Basic Data Acquisition System

## Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision C (December, 2008) to Revision D	Page
• Removed all notes regarding MSOP-8 package status. MSOP-8 package released at time of document revision .....	1
• Changed <i>Storage Temperature Range</i> absolute minimum value from $-55^{\circ}\text{C}$ to $-65^{\circ}\text{C}$ .....	2
• Added test condition to <i>Line Regulation, All other devices</i> specification .....	4
• Added <i>Load Regulation</i> test condition and <i>Over Temperature</i> specifications .....	4
• Added typical characteristic graph, <i>Quiescent Current vs Input Voltage</i> (Figure 10) .....	6

**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>
REF5010AID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5010AIDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR
REF5010AIDGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5010AIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5010ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5010IDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5010IDGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5010IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5020AID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5020AIDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5020AIDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR
REF5020AIDGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5020AIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5020AIDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5020ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5020IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5020IDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5020IDGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5020IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5020IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5025AID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5025AIDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5025AIDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5025AIDGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5025AIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

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>
REF5025AIDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5025ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5025IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5025IDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5025IDGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5025IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5025IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5030AID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5030AIDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5030AIDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5030AIDGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5030AIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5030AIDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5030ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5030IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5030IDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5030IDGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5030IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5030IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5040AID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5040AIDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5040AIDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5040AIDGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5040AIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5040AIDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5040ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

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>
REF5040IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5040IDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5040IDGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5040IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5040IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5045AID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5045AIDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5045AIDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR
REF5045AIDGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5045AIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5045AIDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5045ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5045IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5045IDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5045IDGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5045IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5045IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5050AID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5050AIDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5050AIDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5050AIDGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5050AIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5050AIDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5050ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5050IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5050IDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

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>
REF5050IDGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5050IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
REF5050IDRG4	ACTIVE	SOIC	D	8	2500	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), Pb-Free (RoHS Exempt), 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.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**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.

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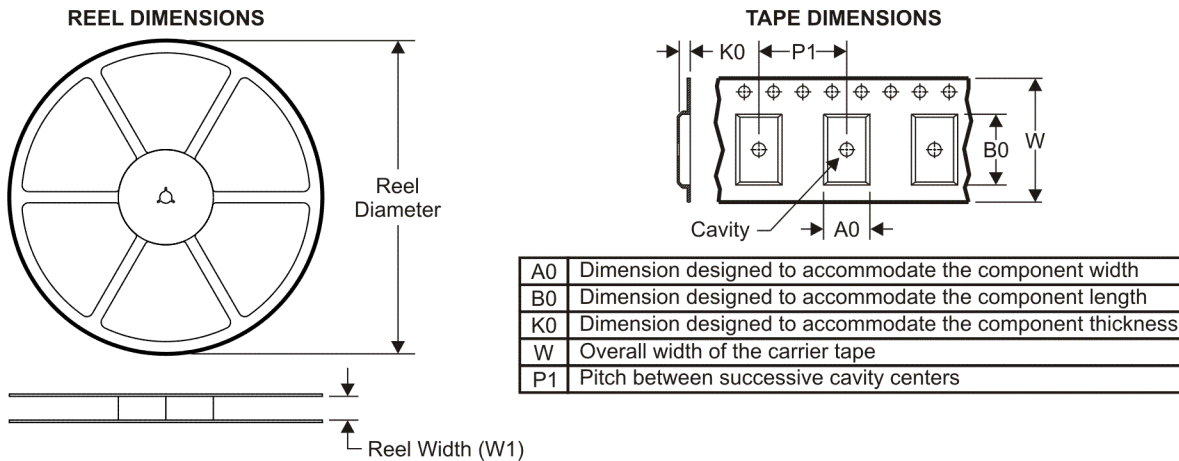
**OTHER QUALIFIED VERSIONS OF REF5020, REF5040, REF5050 :**

- Enhanced Product: [REF5020-EP](#), [REF5040-EP](#), [REF5050-EP](#)

NOTE: Qualified Version Definitions:

- Enhanced Product - Supports Defense, Aerospace and Medical Applications

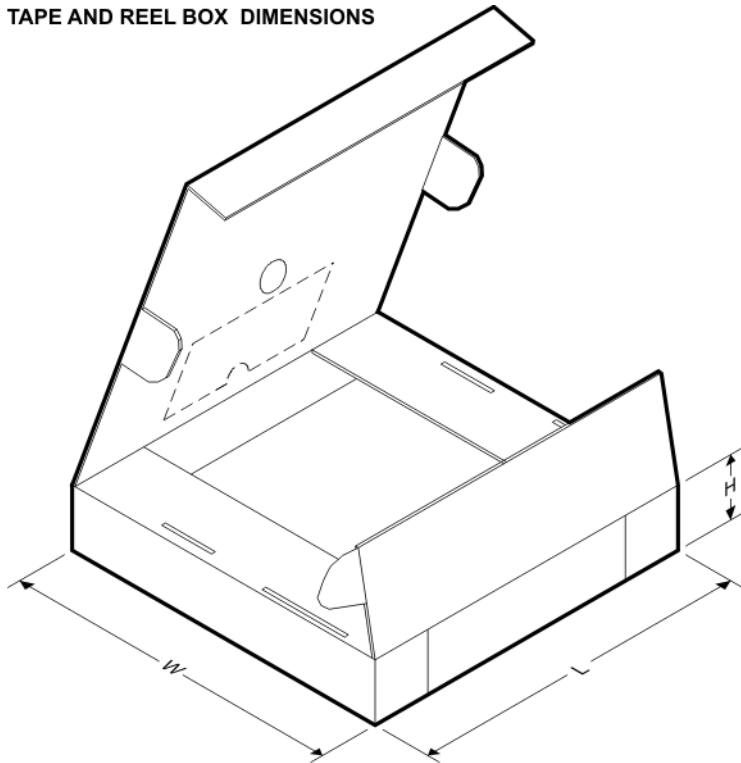


**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
REF5010AIDGKT	MSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5010IDGKR	MSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5010IDGKT	MSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5010IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
REF5020AIDGKT	MSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5020AIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
REF5020IDGKR	MSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5020IDGKT	MSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5020IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
REF5025AIDGKT	MSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5025AIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
REF5025IDGKR	MSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5025IDGKT	MSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5025IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
REF5030AIDGKR	MSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5030AIDGKT	MSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5030AIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
REF5030IDGKR	MSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
REF5030IDGKT	MSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5030IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
REF5040AIDGKT	MSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5040AIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
REF5040IDGKR	MSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5040IDGKT	MSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5040IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
REF5045AIDGKT	MSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5045AIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
REF5045IDGKR	MSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5045IDGKT	MSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5045IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
REF5050AIDGKT	MSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5050AIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
REF5050IDGKR	MSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5050IDGKT	MSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
REF5050IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

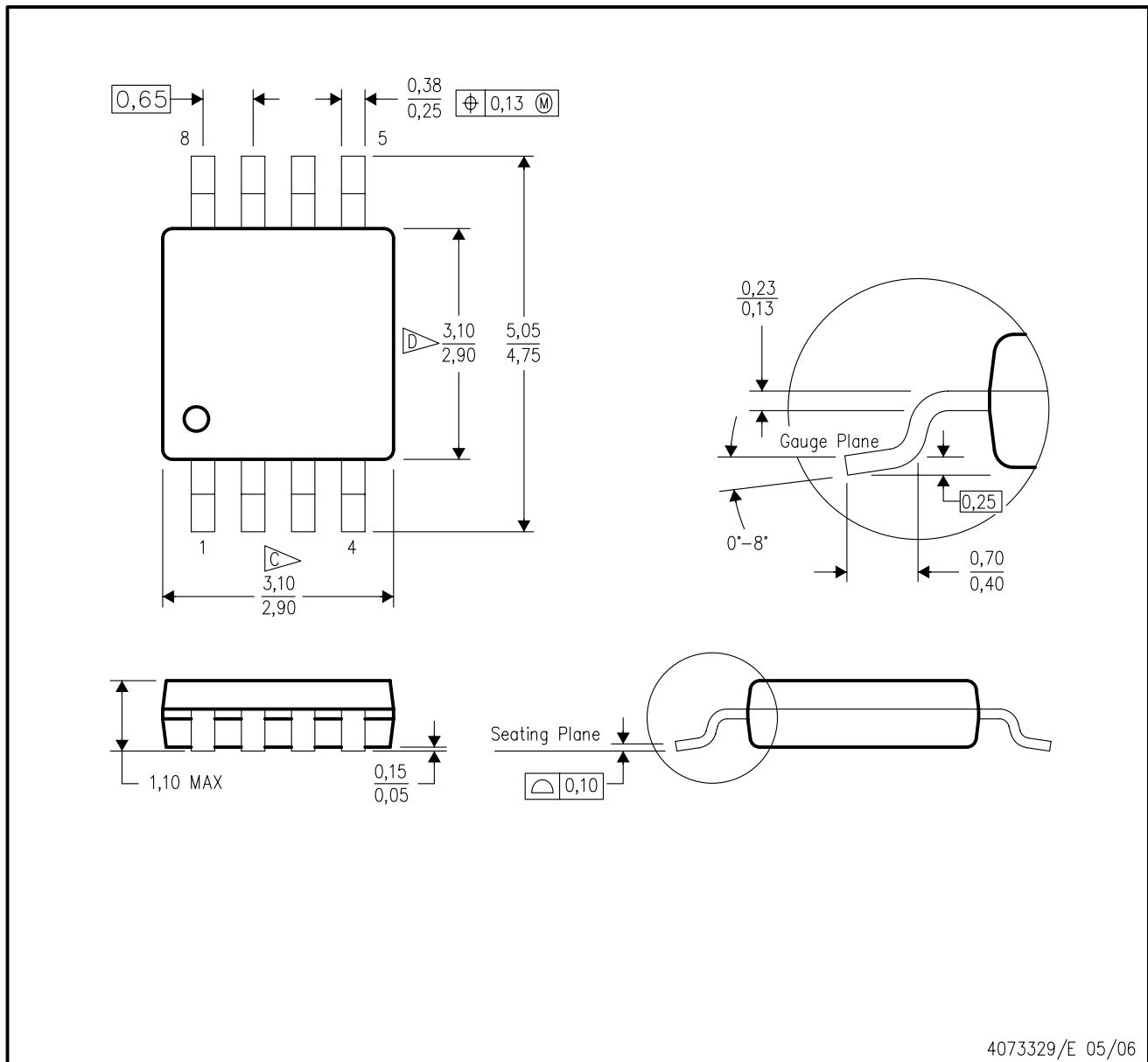
**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
REF5010AIDGKT	MSOP	DGK	8	250	190.5	212.7	31.8
REF5010IDGKR	MSOP	DGK	8	2500	346.0	346.0	29.0
REF5010IDGKT	MSOP	DGK	8	250	190.5	212.7	31.8
REF5010IDR	SOIC	D	8	2500	346.0	346.0	29.0
REF5020AIDGKT	MSOP	DGK	8	250	190.5	212.7	31.8
REF5020AIDR	SOIC	D	8	2500	346.0	346.0	29.0
REF5020IDGKR	MSOP	DGK	8	2500	346.0	346.0	29.0
REF5020IDGKT	MSOP	DGK	8	250	190.5	212.7	31.8
REF5020IDR	SOIC	D	8	2500	346.0	346.0	29.0
REF5025AIDGKT	MSOP	DGK	8	250	190.5	212.7	31.8
REF5025AIDR	SOIC	D	8	2500	346.0	346.0	29.0
REF5025IDGKR	MSOP	DGK	8	2500	346.0	346.0	29.0
REF5025IDGKT	MSOP	DGK	8	250	190.5	212.7	31.8
REF5025IDR	SOIC	D	8	2500	346.0	346.0	29.0
REF5030AIDGKR	MSOP	DGK	8	2500	346.0	346.0	29.0
REF5030AIDGKT	MSOP	DGK	8	250	190.5	212.7	31.8
REF5030AIDR	SOIC	D	8	2500	346.0	346.0	29.0
REF5030IDGKR	MSOP	DGK	8	2500	346.0	346.0	29.0
REF5030IDGKT	MSOP	DGK	8	250	190.5	212.7	31.8
REF5030IDR	SOIC	D	8	2500	346.0	346.0	29.0
REF5040AIDGKT	MSOP	DGK	8	250	190.5	212.7	31.8
REF5040AIDR	SOIC	D	8	2500	346.0	346.0	29.0
REF5040IDGKR	MSOP	DGK	8	2500	346.0	346.0	29.0
REF5040IDGKT	MSOP	DGK	8	250	190.5	212.7	31.8
REF5040IDR	SOIC	D	8	2500	346.0	346.0	29.0
REF5045AIDGKT	MSOP	DGK	8	250	190.5	212.7	31.8
REF5045AIDR	SOIC	D	8	2500	346.0	346.0	29.0
REF5045IDGKR	MSOP	DGK	8	2500	346.0	346.0	29.0
REF5045IDGKT	MSOP	DGK	8	250	190.5	212.7	31.8
REF5045IDR	SOIC	D	8	2500	346.0	346.0	29.0
REF5050AIDGKT	MSOP	DGK	8	250	190.5	212.7	31.8
REF5050AIDR	SOIC	D	8	2500	346.0	346.0	29.0
REF5050IDGKR	MSOP	DGK	8	2500	346.0	346.0	29.0
REF5050IDGKT	MSOP	DGK	8	250	190.5	212.7	31.8
REF5050IDR	SOIC	D	8	2500	346.0	346.0	29.0

DGK (S-PDSO-G8)

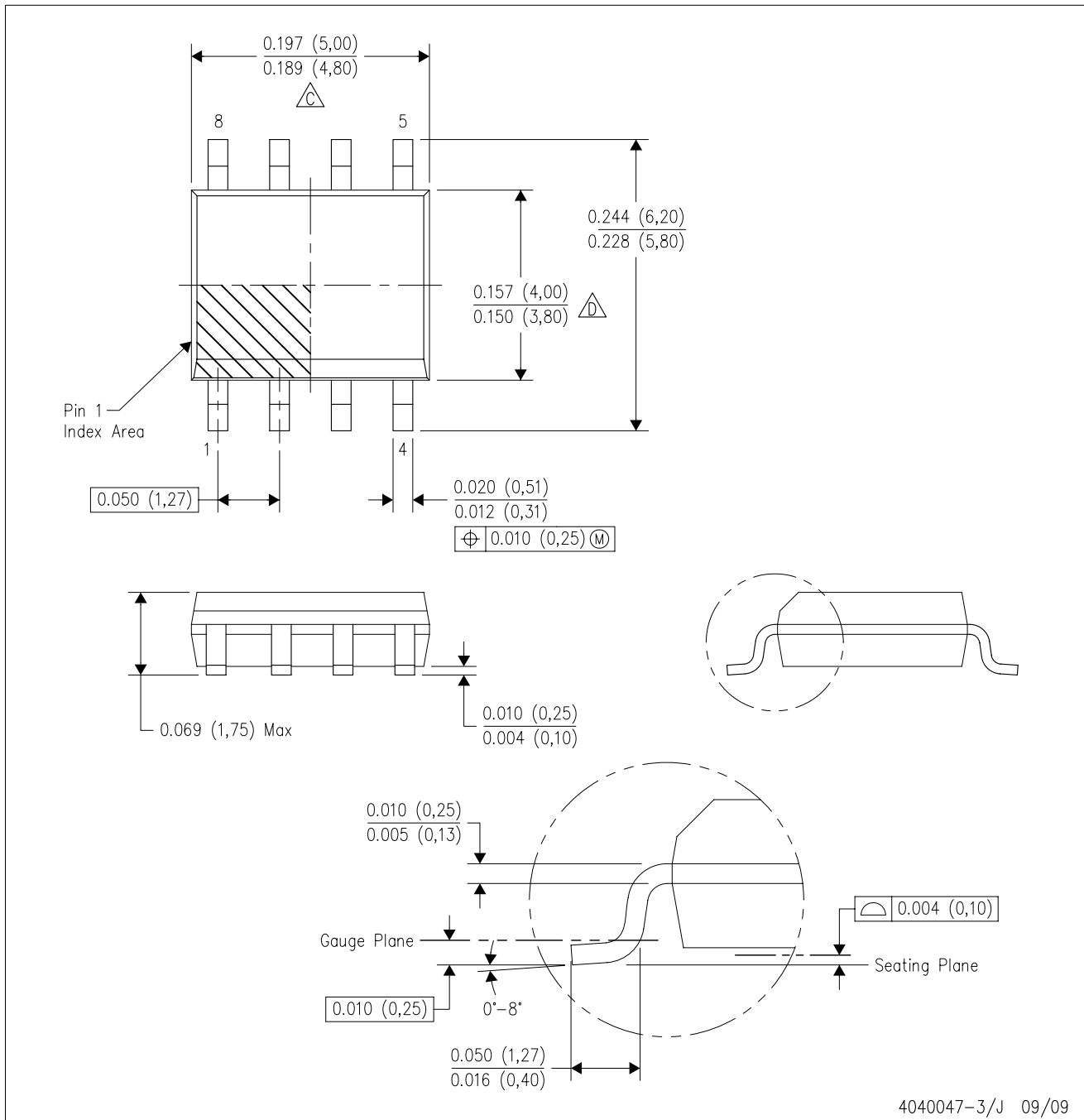
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
  - E. Falls within JEDEC MO-187 variation AA, except interlead flash.

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - $\triangle C$  Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
  - $\triangle D$  Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
  - E. Reference JEDEC MS-012 variation AA.

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DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>	Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
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Interface	<a href="http://interface.ti.com">interface.ti.com</a>	Energy	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>	Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>	Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>	Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
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