LOW NOISE, VERY LOW DRIFT, PRECISION VOLTAGE REFERENCE

Check for Samples: REF5025-HT

FEATURES

- **Low Temperature Drift: 40 ppm/°C**
- **Low Noise: 3 μV_{PP}/V**
- **High Output Current: ±7 mA**

APPLICATIONS

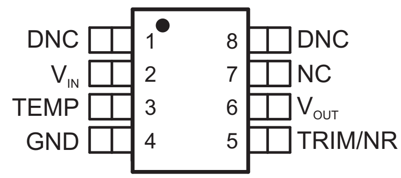
- **Down-Hole Drilling**
- **High Temperature Environments**

SUPPORTS EXTREME TEMPERATURE APPLICATIONS

- **Controlled Baseline**
- **One Assembly/Test Site**
- **One Fabrication Site**
- **Available in Extreme (–55°C/210°C) Temperature Range**[(1)]
- **Extended Product Life Cycle**
- **Extended Product-Change Notification**
- **Product Traceability**
- **Texas Instruments high temperature products utilize highly optimized silicon (die) solutions with design and process enhancements to maximize performance over extended temperatures.**

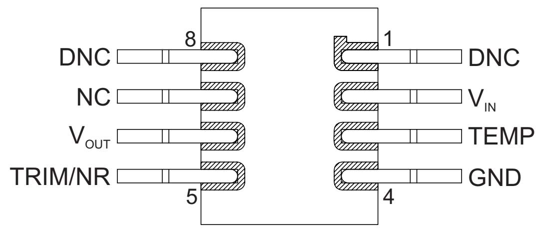
(1) Custom temperature ranges available

HKJ PACKAGE (TOP VIEW)



DNC = Do not connect
NC = No internal connection

HKQ PACKAGE (TOP VIEW)



HKQ as formed or HKJ mounted dead bug

DESCRIPTION

The REF5025 is a low-noise, low-drift, very high precision voltage reference. This reference is capable of both sinking and sourcing, and is very robust with regard to line and load changes.

Temperature drift (40 ppm/°C) from –55°C to 210°C is achieved using proprietary design techniques. These features combined with very low noise make the REF5025 ideal for use in down-hole drilling applications.

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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.

BARE DIE INFORMATION

DIE THICKNESS	BACKSIDE FINISH	BACKSIDE POTENTIAL	BOND PAD METALLIZATION COMPOSITION	BOND PAD THICKNESS
15 mils.	Silicon with backgrind	GND	Al-Cu (0.5%)	598 nm

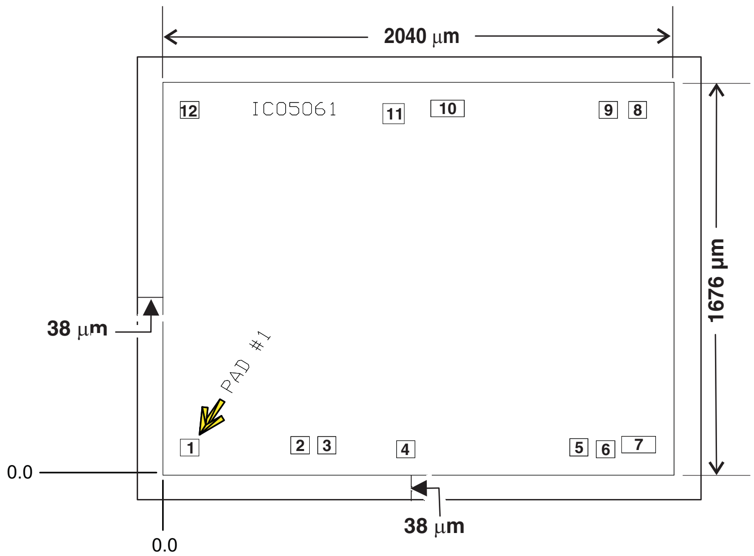

Table 1. Bond Pad Coordinates in Microns

DISCRIPTION	PAD NUMBER	X min	Y min	X max	Y max
NC	1	35.45	46.55	111.45	122.55
NC	2	496.75	56.55	572.75	132.55
VIN	3	607.45	56.55	683.45	132.55
NC	4	937.9	39.4	1013.9	115.4
TEMP	5	1660.1	47.2	1736.1	123.2
GND	6	1770.9	38.85	1847.05	115
GND	7	1877.1	59.6	2016.8	135.6
TRIM/NR	8	1904.65	1553.4	1980.65	1629.4
NC	9	1782.15	1553.4	1858.15	1629.4
VOUT	10	1080.2	1559.85	1219.9	1636
VOUT	11	880.25	1543.55	956.25	1619.55
NC	12	35.45	1553.45	111.45	1629.45

ORDERING INFORMATION(1)

T_A	PACKAGE	ORDERABLE PART NUMBER	TOP-SIDE MARKING
–55°C to 210°C	KGD (bare die)	REF5025SKGD1	NA
	HKJ	REF5025SHKJ	REF5025SHKJ
	HKQ	REF5025SHKQ	REF5025SHKQ

(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.

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ABSOLUTE MAXIMUM RATINGS(1)

			UNIT
Input Voltage		18	V
Output Short-Circuit		30	mA
Operating Temperature Range		–55 to 210	°C
Storage Temperature Range		–65 to 210	°C
Junction Temperature (T_J max)		210	°C
ESD Rating	Human Body Model (HBM)	3000	V
	Charged Device Model (CDM)	1000	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.

THERMAL CHARACTERISTICS FOR HKJ OR HKQ PACKAGE

over operating free-air temperature range (unless otherwise noted)

PARAMETER			MIN	TYP	MAX	UNIT
θ_{JC}	Junction-to-case thermal resistance	to ceramic side of case			5.7	°C/W
		to top of case lid (metal side of case)			13.7	

ELECTRICAL CHARACTERISTICS

T_A = 25°C, I_{LOAD} = 0, C_L = 1 µF, V_{IN} = 3.25 V to 18 V (unless otherwise noted).

PARAMETER		CONDITIONS	T_A = –55 to 125°C			T_A = 210°C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
OUTPUT VOLTAGE (2.5 V)									
Output voltage	V_{OUT}			2.5			2.5		V
Initial accuracy(1)		V_{IN} = 3.25 V	0		0.9		0.14		%
NOISE									
Output voltage noise		f = 0.1 Hz to 10 Hz		7.5					µV_{PP}
OUTPUT VOLTAGE TEMPERATURE DRIFT									
Output voltage temperature drift(2)	dV_{OUT}/dT	Calculated from –55°C to 210°C						40	ppm/°C
LINE REGULATION									
Line regulation	dV_{OUT}/dV_{IN}	From V_{IN} = 3.25 V to V_{IN} = 18 V		1	2.2		63	215	ppm/V
LOAD REGULATION									
Load regulation	dV_{OUT}/dI_{LOAD}	–7 mA < I_{LOAD} < 10 mA, V_{IN} = 3.25 V		20	50		20	75	ppm/mA
SHORT-CIRCUIT CURRENT									
Short-circuit current	I_{SC}	V_{OUT} = 0 V		25			11		mA
TEMP PIN									
Voltage output		At T_A = 25°C		575					mV
Temperature sensitivity(3)				2.64					mV/°C
TURN-ON SETTLING TIME									
Turn-on settling time		To 0.1% with C_L = 1 µF		200					µs
POWER SUPPLY									
Supply voltage	V_S		3.25		18	3.25		18	V
Quiescent current				0.8	1.2			1.5	mA
TEMPERATURE RANGE									
Specified range		–55°C to 210°C							
Operating range		–55°C to 210°C							

(1) Refer to Figure 5 of the TYPICAL CHARACTERISTICS.
(2) Refer to Figure 4 of the TYPICAL CHARACTERISTICS.
(3) Refer to Figure 10 of the TYPICAL CHARACTERISTICS.

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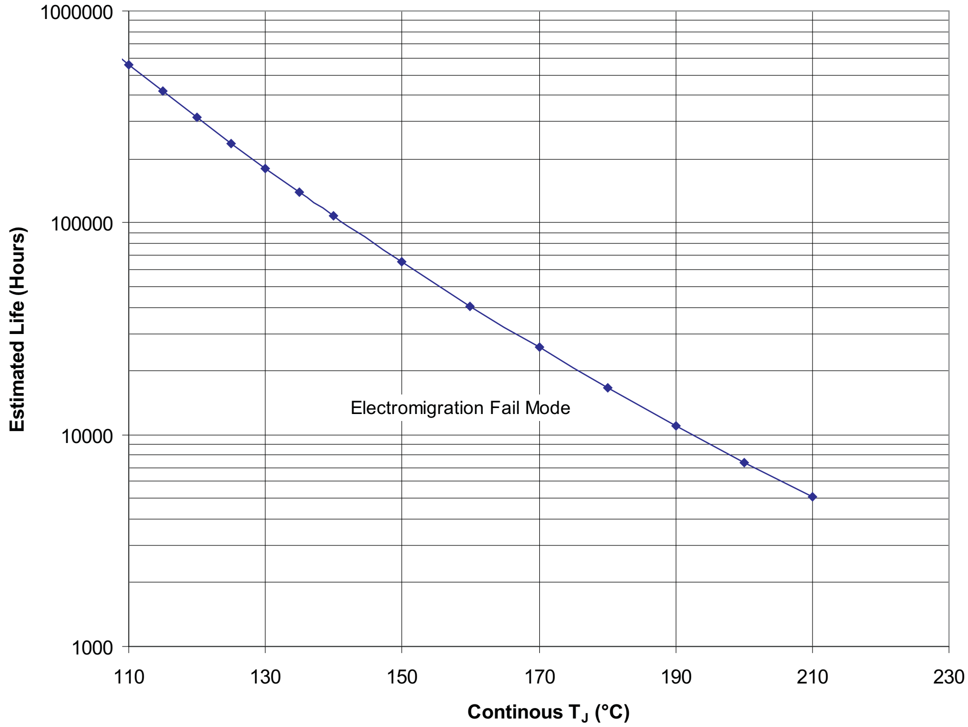

Figure 1. REF5025SKGD1 Operating Life Derating Chart

Notes:

1. See datasheet for Absolute Maximum and minimum Recommended Operating Conditions.
2. Silicon operating life design goal is 10 years at 105°C junction temperature (does not include package interconnect life).

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TYPICAL CHARACTERISTICS

T_A = 25°C, I_{LOAD} = 0, V_S = 3.25 V (unless otherwise noted).

TEMPERATURE DRIFT (0°C to 85°C)

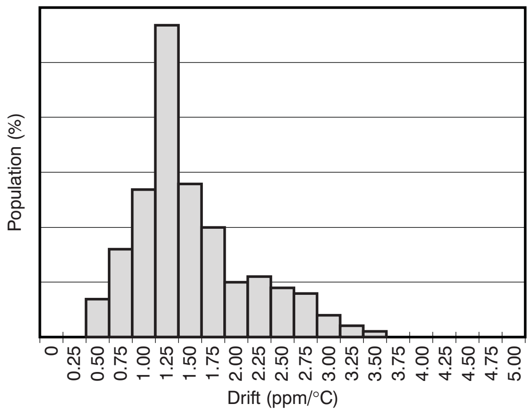

Figure 2.

TEMPERATURE DRIFT (–40°C to 125°C)

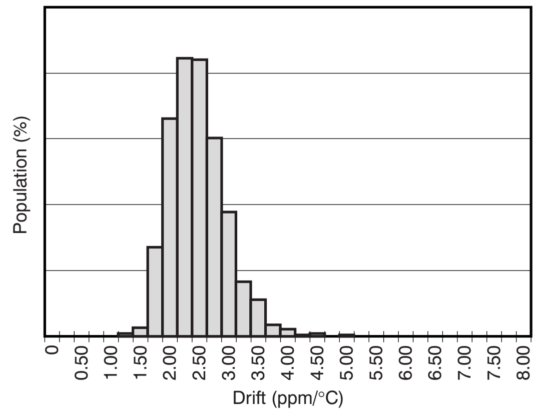

Figure 3.

TEMPERATURE DRIFT (–55°C to 210°C)

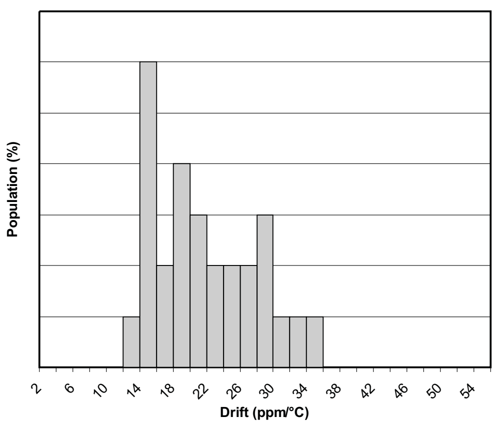

Figure 4.

OUTPUT VOLTAGE INITIAL ACCURACY (AT 210°C)

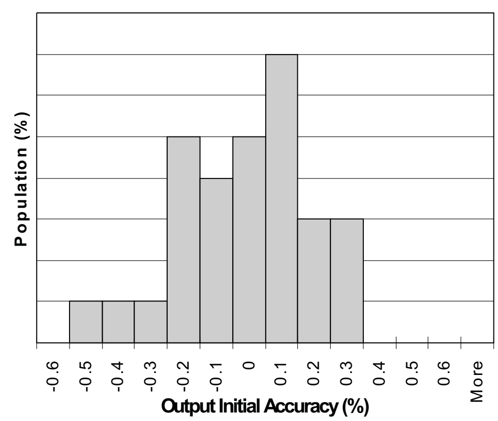

Figure 5.

TYPICAL CHARACTERISTICS (continued)

T_A = 25°C, I_{LOAD} = 0, V_S = 3.25 V (unless otherwise noted).

OUTPUT VOLTAGE ACCURACY vs TEMPERATURE

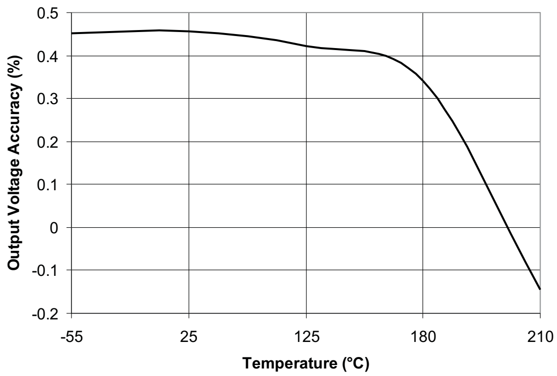

Figure 6.

POWER-SUPPLY REJECTION RATIO vs FREQUENCY

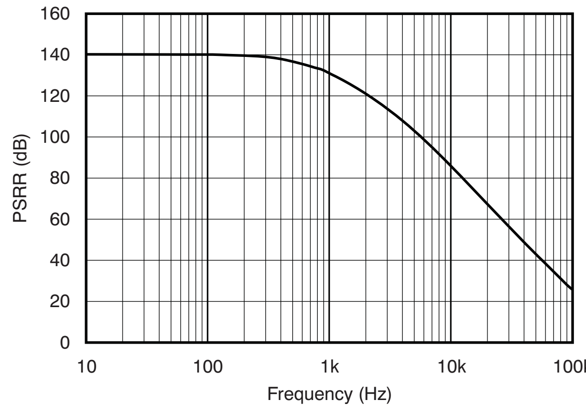

Figure 7.

DROPOUT VOLTAGE vs LOAD CURRENT

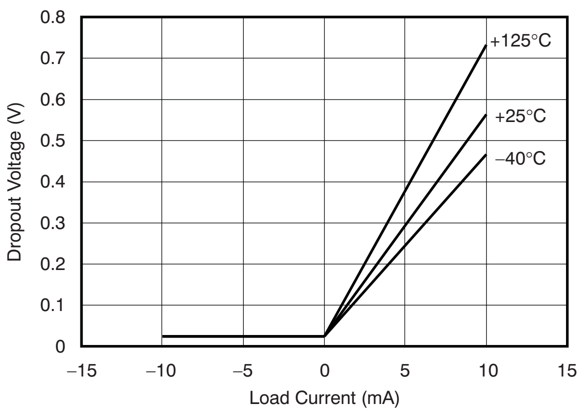

Figure 8.

OUTPUT VOLTAGE vs LOAD CURRENT

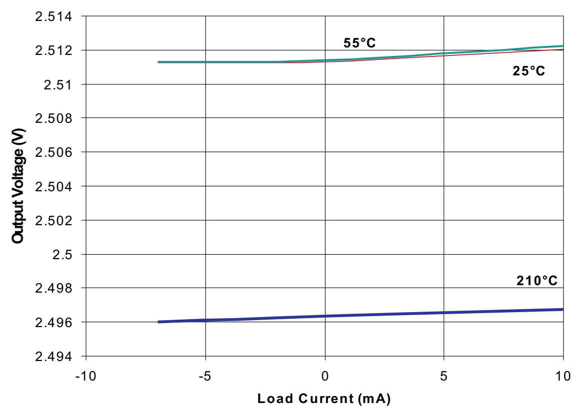

Figure 9.

TEMP PIN OUTPUT VOLTAGE vs TEMPERATURE

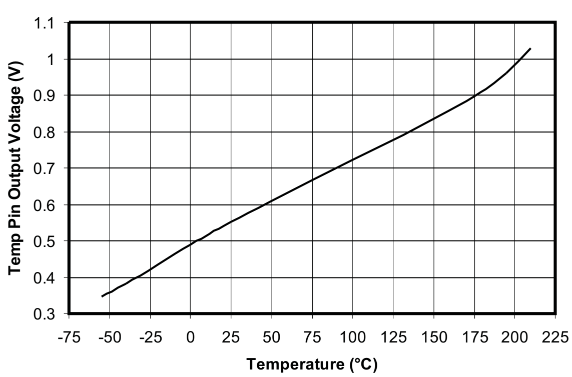

Figure 10.

QUIESCENT CURRENT vs TEMPERATURE

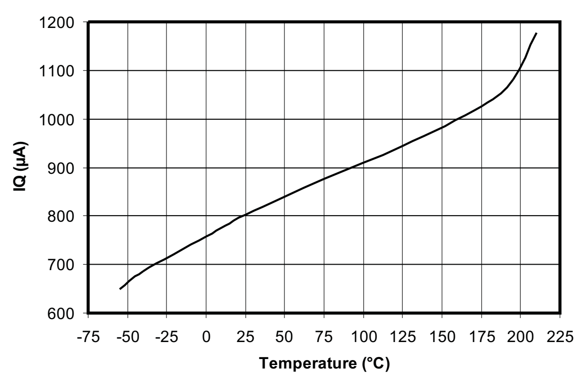

Figure 11.

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TYPICAL CHARACTERISTICS (continued)

T_A = 25°C, I_{LOAD} = 0, V_S = 3.25 V (unless otherwise noted).

QUIESCENT CURRENT vs INPUT VOLTAGE

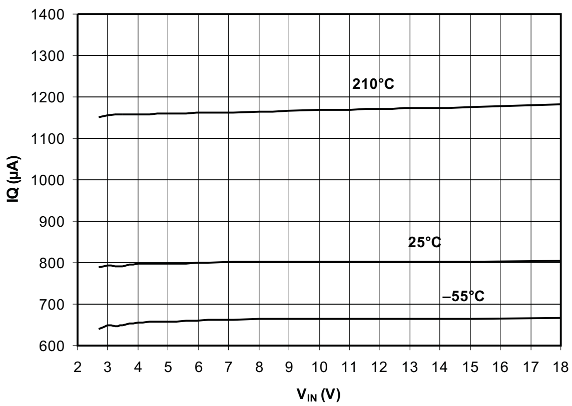

Figure 12.

LINE REGULATION vs TEMPERATURE

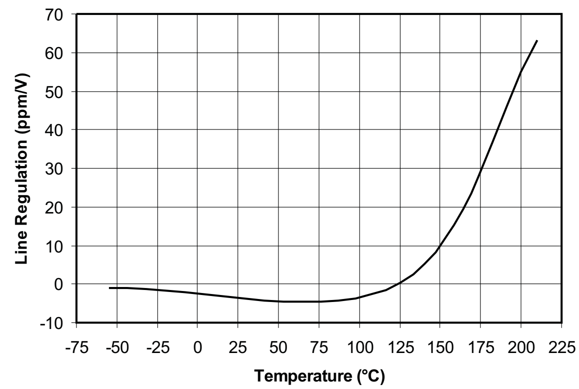

Figure 13.

SHORT-CIRCUIT CURRENT vs TEMPERATURE

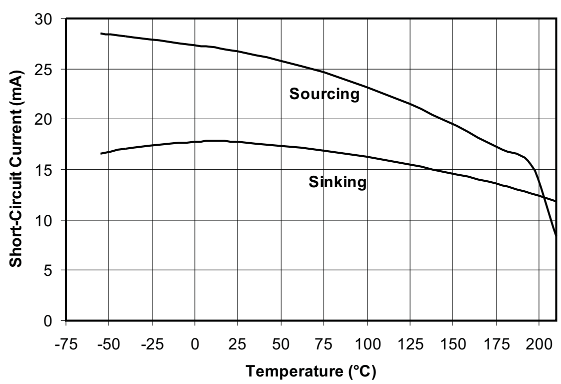

Figure 14.

NOISE

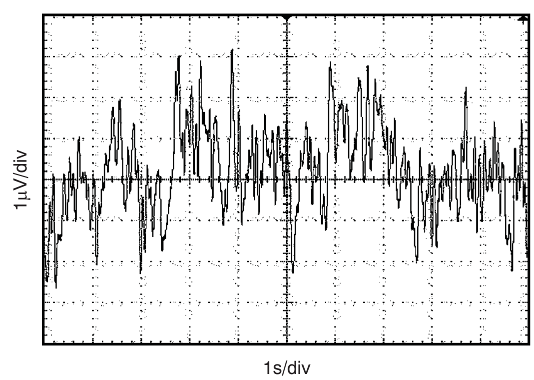

Figure 15.

STARTUP (REF5025, C_L = 1 µF)

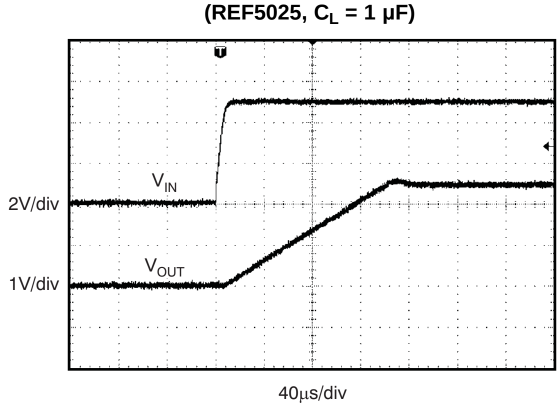

Figure 16.

STARTUP (REF5025, C_L = 10 µF)

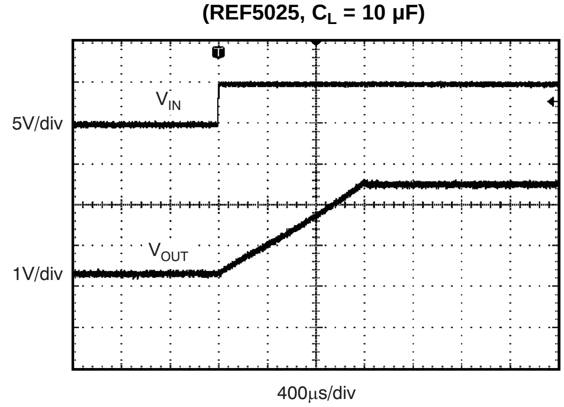

Figure 17.

TYPICAL CHARACTERISTICS (continued)

T_A = 25°C, I_{LOAD} = 0, V_S = 3.25 V (unless otherwise noted).

LOAD TRANSIENT
(C_L = 1 µF, I_{OUT} = 1 mA)

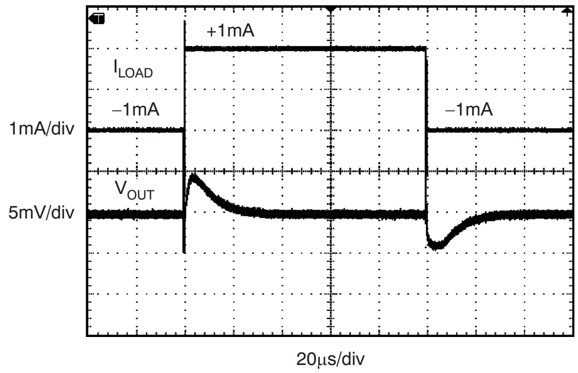

Figure 18.

LOAD TRANSIENT
(C_L = 1 µF, I_{OUT} = 10 mA)

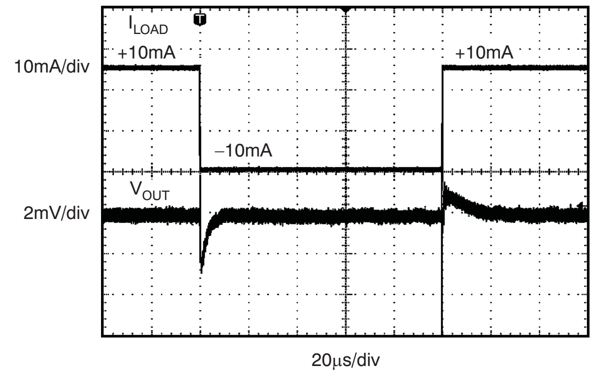

Figure 19.

LOAD TRANSIENT
(C_L = 10 µF, I_{OUT} = 1 mA)

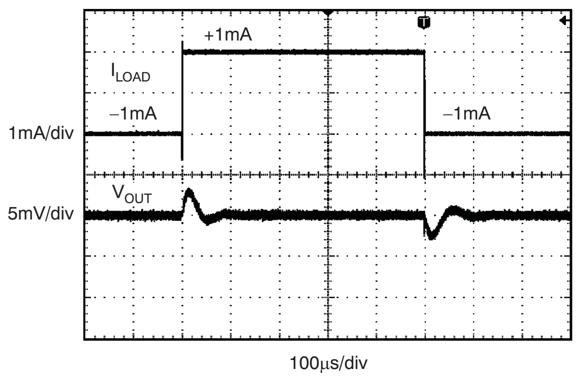

Figure 20.

LOAD TRANSIENT
(C_L = 10 µF, I_{OUT} = 10 mA)

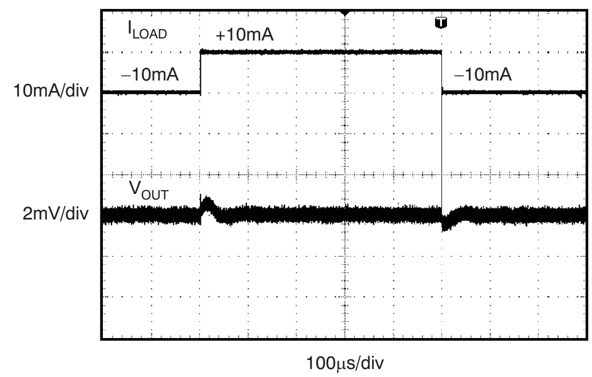

Figure 21.

LINE TRANSIENT
(C_L = 1 µF)

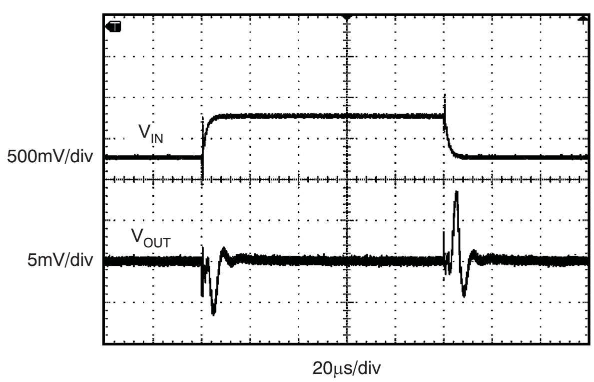

Figure 22.

LINE TRANSIENT
(C_L = 10 µF)

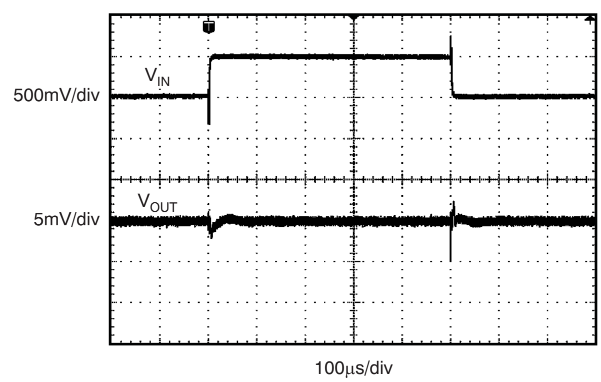

Figure 23.

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APPLICATION INFORMATION

The REF5025 is a low-noise, precision bandgap voltage reference that is specifically designed for excellent initial voltage accuracy and drift. Figure 24 shows a simplified block diagram of the REF5025.

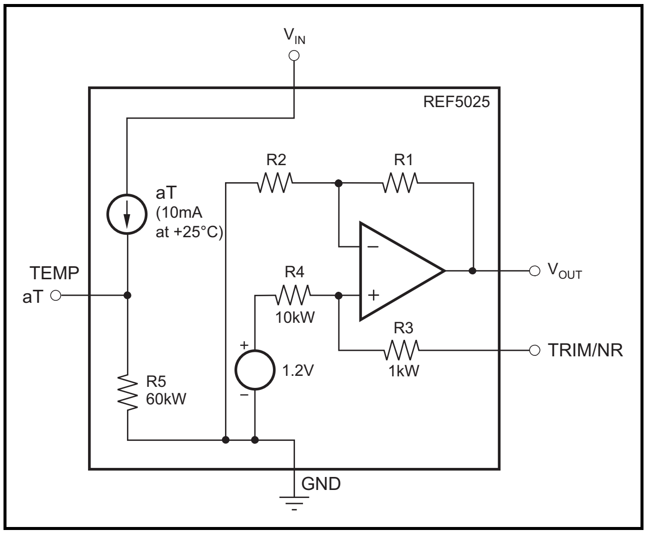

Figure 24. REF5025 Simplified Block Diagram

BASIC CONNECTIONS

Figure 25 shows the typical connections for the REF5025. A supply bypass capacitor ranging between 1 μF to 10 μF is recommended. A 1-μF to 50-μF, low-ESR output capacitor (C_L) must be connected from V_{OUT} to GND. The ESR value should be less than or equal to 1.5 Ω. The ESR minimizes gain peaking of the internal 1.2-V reference and thus reduces noise at the V_{OUT} pin.

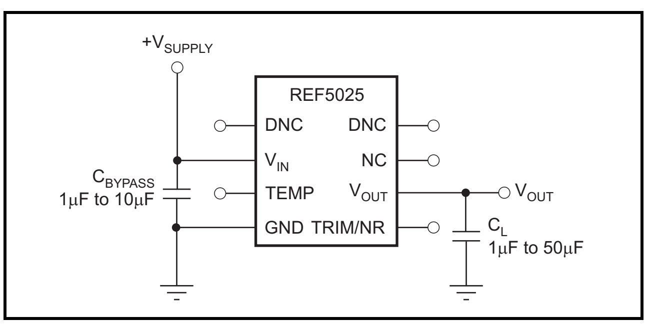

Figure 25. Basic Connections

SUPPLY VOLTAGE

The REF5025 features extremely low dropout voltage. For loaded conditions, a typical dropout voltage versus load plot is shown in Figure 8 of *Typical Characteristics*.

USING THE TRIM/NR PIN

The REF5025 provides a very accurate voltage output. However, V_{OUT} can be adjusted to reduce noise and shift the output voltage from the nominal value by configuring the trim and noise reduction pin (TRIM/NR, pin 5). The TRIM/NR pin provides a ±15-mV adjustment of the device bandgap, which produces a ±15-mV change on the V_{OUT} pin. Figure 26 shows a typical circuit using the TRIM/NR pin to adjust V_{OUT}. When using this technique, the temperature coefficients of the resistors can degrade the temperature drift at the output.

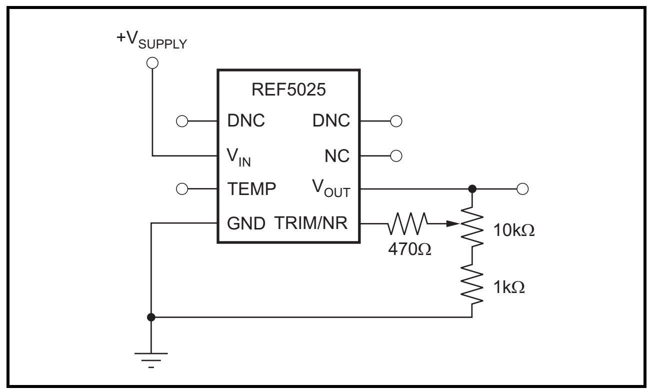

Figure 26. V_{OUT} Adjustment Using TRIM/NR Pin

The REF5025 allows access to the bandgap through the TRIM/NR pin. Placing a capacitor from the TRIM/NR pin to GND (as Figure 27 illustrates) in combination with the internal 1-kΩ resistor creates a low-pass filter that lowers the overall noise measured on the V_{OUT} pin. A capacitance of 1 μF is suggested for a low-pass filter with a corner frequency of 14.5 Hz. Higher capacitance results in a lower cutoff frequency.

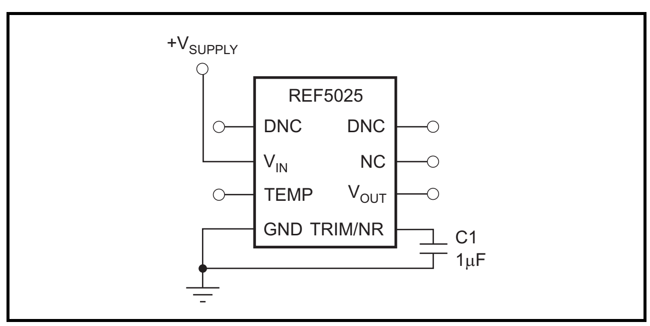

Figure 27. Noise Reduction Using TRIM/NR Pin

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TEMPERATURE DRIFT

The REF5025 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:

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

TEMPERATURE MONITORING

The temperature output terminal (TEMP, pin 3) provides a temperature-dependent voltage output with approximately 60-kΩ source impedance. As seen in Figure 10, the output voltage follows the nominal relationship:

$$V_{TEMP\ PIN} = 509\text{ mV} + 2.64 \times T(°C) \quad (2) \quad (2)$$

(For –55°C to 125°C only. Refer to Figure 10 of the TYPICAL CHARACTERISTICS for 125°C to 210°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 79-mV change in voltage at the TEMP pin.

The TEMP pin has high output impedance (see Figure 24). Loading this pin with a low-impedance circuit induces a measurement error; however, it does not have any effect on V_{OUT} accuracy. To avoid errors caused by low-impedance loading, buffer the TEMP pin output with a suitable low-temperature drift op amp as shown in Figure 28.

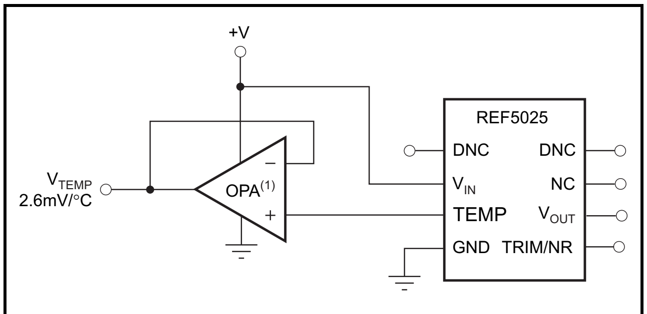

Figure 28. Buffering the TEMP Pin Output

POWER DISSIPATION

The REF5025 is specified to deliver current loads of ±10 mA over the specified input voltage range. The temperature of the device increases according to the equation:

$$T_J = T_A + P_D \times \theta_{JA} \quad (3) \quad (3)$$

Where:

T_J = Junction temperature (°C)

T_A = Ambient temperature (°C)

P_D = Power dissipated (W)

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

The REF5025 junction temperature must not exceed the absolute maximum rating of 210°C.

NOISE PERFORMANCE

Typical 0.1-Hz to 10-Hz voltage noise for each member of the REF5025 is specified in the Electrical Characterisitics 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.

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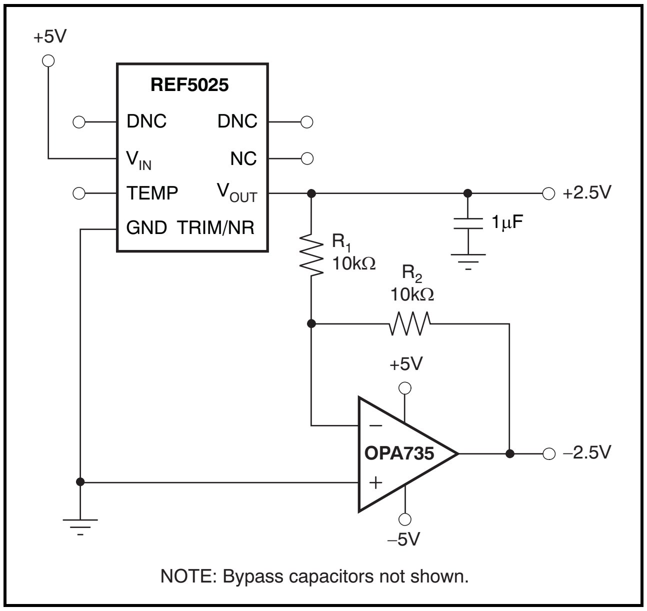
APPLICATION CIRCUITS

NEGATIVE REFERENCE VOLTAGE

For applications requiring a negative and positive reference voltage, the REF5025 and OPA735 can be used to provide a dual-supply reference from a 5-V supply. Figure 29 shows the REF5025 used to provide a 2.5-V supply reference voltage. The low drift performance of the REF5025 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.

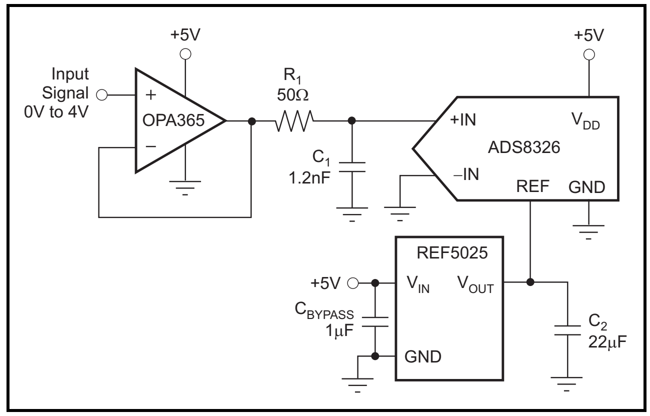


A. OPA735 has not been characterized or tested at 210°C.

Figure 29. The REF5025 and OPA735 Create Positive and Negative Reference Voltages

DATA ACQUISITION

Data acquisition systems often require stable voltage references to maintain accuracy. The REF5025 features low noise, very low drift, and high initial accuracy for high-performance data converters. Figure 30 shows the REF5025 in a basic data acquisition system.



A. OPA365 and ADS8326 have not been characterized or tested at 210°C.

Figure 30. Basic Data Acquisition System

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/ Ball Finish	MSL Peak Temp (3)	Samples (Requires Login)
REF5025SHKJ	ACTIVE	CFP	HKJ	8	1	TBD	Call TI	N / A for Pkg Type	
REF5025SHKQ	ACTIVE	CFP	HKQ	8	25	TBD	AU	N / A for Pkg Type	
REF5025SKGD1	ACTIVE	XCEPT	KGD	0	195	TBD	Call TI	N / A for Pkg Type	

(1) 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.

(2) 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)

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

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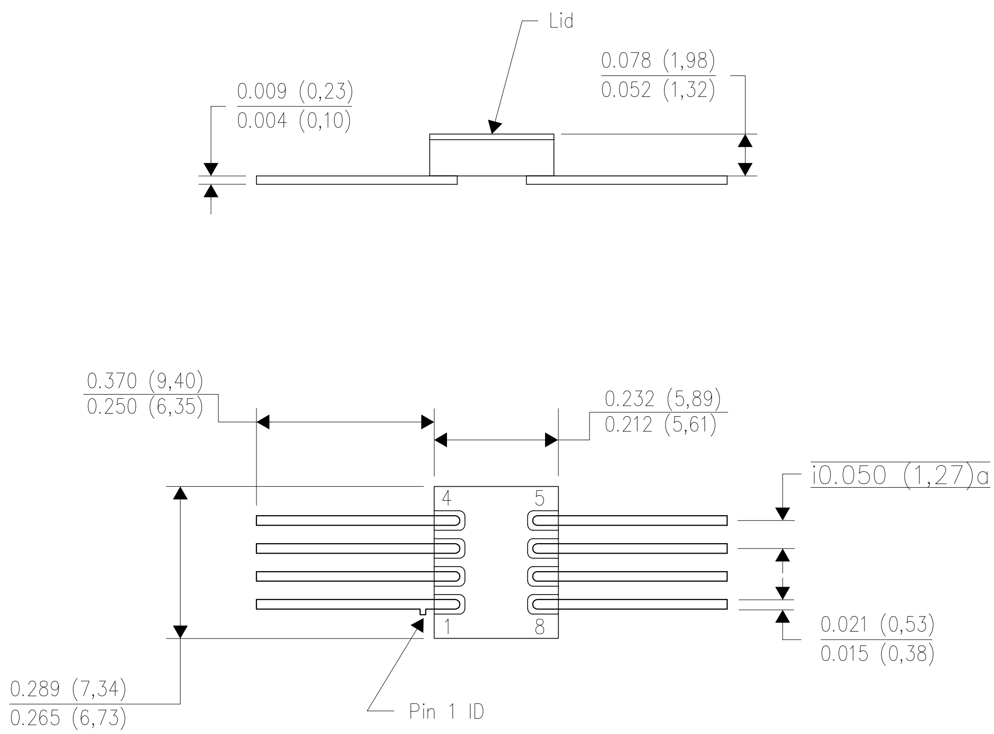
OTHER QUALIFIED VERSIONS OF REF5025-HT :

- Catalog: REF5025
- Enhanced Product: REF5025-EP

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

HKJ (R–CDFP–F8) CERAMIC DUAL FLATPACK



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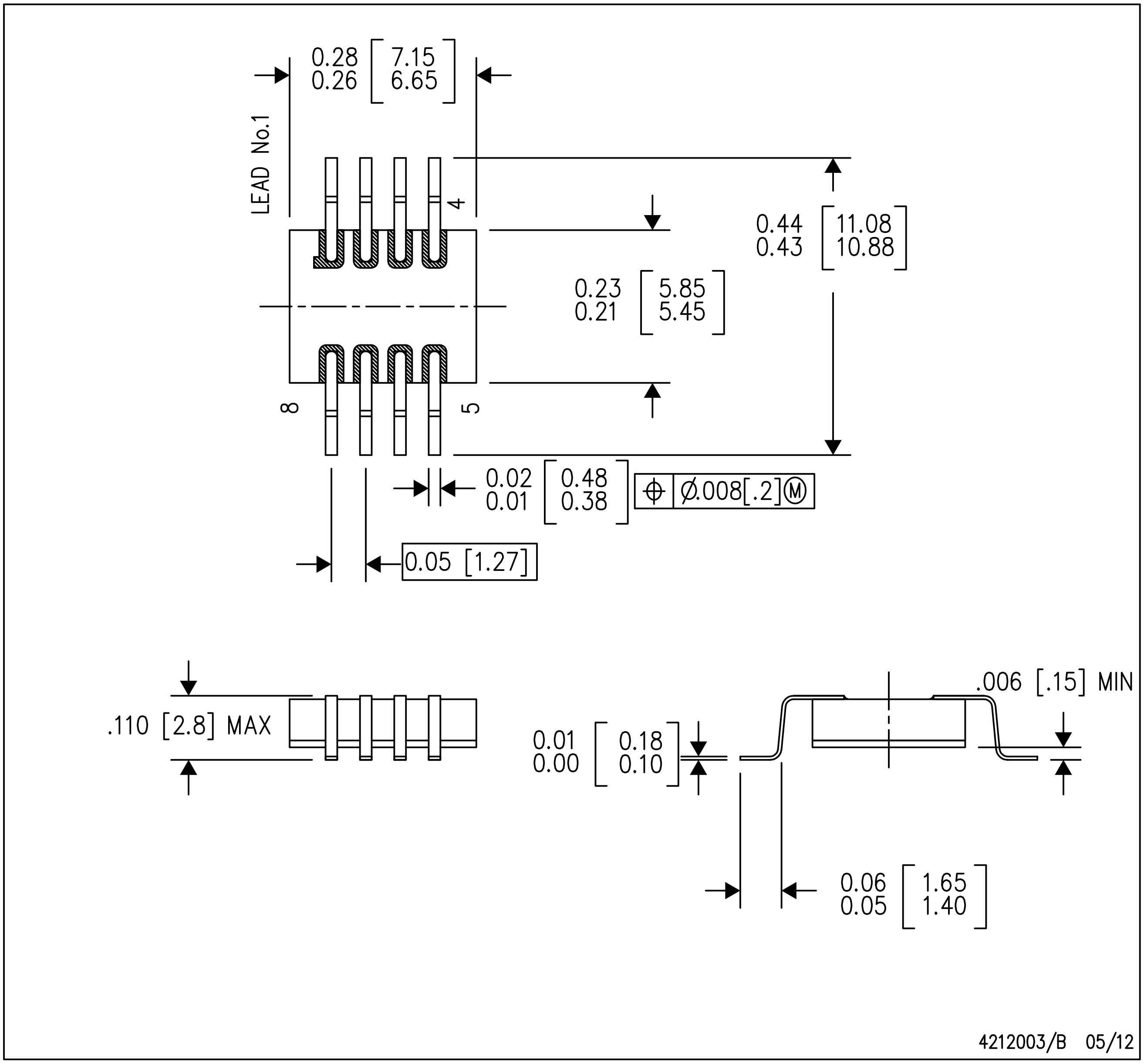
NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. This package can be hermetically sealed with a metal lid.
- D. The terminals will be gold plated.

HKQ (R–CDFP–G8) CERAMIC GULL WING



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package can be hermetically sealed with a metal lid.
D. The terminals will be gold plated.
E. Lid is not connected to any lead.

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