



# THE DATASHEET OF REF02AP





# +5V Precision VOLTAGE REFERENCE

## FEATURES

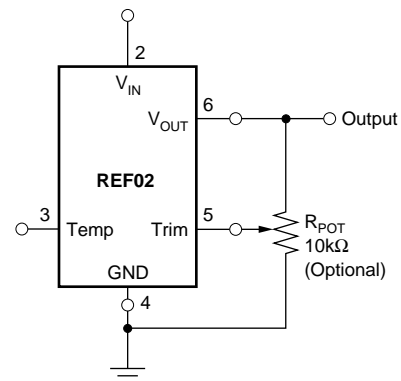
- **OUTPUT VOLTAGE:** +5V  $\pm 0.2\%$  max
- **EXCELLENT TEMPERATURE STABILITY:** 10ppm/ $^{\circ}\text{C}$  max ( $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ )
- **LOW NOISE:**  $10\mu\text{V}_{\text{pp}}$  max (0.1Hz to 10Hz)
- **EXCELLENT LINE REGULATION:** 0.01%/V max
- **EXCELLENT LOAD REGULATION:** 0.008%/mA max
- **LOW SUPPLY CURRENT:** 1.4mA max
- **SHORT-CIRCUIT PROTECTED**
- **WIDE SUPPLY RANGE:** 8V to 40V
- **INDUSTRIAL TEMPERATURE RANGE:**  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$
- **PACKAGE OPTIONS:** DIP-8, SO-8

## APPLICATIONS

- PRECISION REGULATORS
- CONSTANT CURRENT SOURCE/SINK
- DIGITAL VOLTMETERS
- V/F CONVERTERS
- A/D AND D/A CONVERTERS
- PRECISION CALIBRATION STANDARD
- TEST EQUIPMENT

## DESCRIPTION

The REF02 is a precision 5V voltage reference. The drift is laser trimmed to 10ppm/ $^{\circ}\text{C}$  max over the extended industrial and military temperature range. The REF02 provides a stable 5V output that can be externally adjusted over a  $\pm 6\%$  range with minimal effect on temperature stability. The REF02 operates from a single supply with an input range of 8V to 40V with a very low current drain of 1mA, and excellent temperature stability due to an improved design. Excellent line and load regulation, low noise, low power, and low cost make the REF02 the best choice whenever a 5V voltage reference is required. Available package options are DIP-8 and SO-8. The REF02 is an ideal choice for portable instrumentation, temperature transducers, Analog-to-Digital (A/D) and Digital-to-Analog (D/A) converters, and digital voltmeters.



+5V Reference with Trimmed Output



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# SPECIFICATIONS

## ELECTRICAL

At  $T_A = +25^\circ\text{C}$  and  $V_{IN} = +15\text{V}$  power supply, unless otherwise noted.

PARAMETER	CONDITIONS	REF02A			REF02B			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
<b>OUTPUT VOLTAGE</b> Change with Temperature <sup>(1, 2)</sup> ( $\Delta V_{OT}$ ) -40°C to +85°C	$I_{LOAD} = 0\text{mA}$	4.985	5.0	5.015	4.990	*	5.010	V
<b>OUTPUT VOLTAGE DRIFT<sup>(3)</sup></b> -40°C to +85°C ( $TCV_O$ )			4	15		4	10	$\pm\text{ppm}/^\circ\text{C}$
<b>LONG-TERM STABILITY</b> First 1000h Second 1000h	2000h Test		100 50			100 50		$\pm\text{ppm}$ $\pm\text{ppm}$
<b>OUTPUT ADJUSTMENT RANGE</b>	$R_{POT} = 10\text{k}\Omega^{(6)}$	$\pm 3$	$\pm 6$		*	*		%
<b>CHANGE IN <math>V_O</math> TEMP COEFFICIENT WITH OUTPUT ADJUSTMENT</b> (-55°C to +125°C)	$R_{POT} = 10\text{k}\Omega$		0.7			*		ppm/%
<b>OUTPUT VOLTAGE NOISE</b>	0.1Hz to 10Hz <sup>(5)</sup>		4	10		*	*	$\mu\text{V}_{PP}$
<b>LINE REGULATION<sup>(4)</sup></b> -40°C to +85°C	$V_{IN} = 8\text{V}$ to 33V $V_{IN} = 8.5\text{V}$ to 33V		0.006 0.008	0.010 0.012		*	*	%/V
<b>LOAD REGULATION<sup>(4)</sup></b> -40°C to +85°C	$I_L = 0\text{mA}$ to +10mA $I_L = 0\text{mA}$ to +10mA		0.005 0.007	0.010 0.012		*	0.008 0.010	%/mA
<b>TURN-ON SETTLING TIME</b>	$T_o \pm 0.1\%$ of Final Value		5			*		$\mu\text{s}$
<b>QUIESCENT CURRENT</b>	No Load		1.0	1.4		*	*	mA
<b>LOAD CURRENT (SOURCE)</b>		10	21		*	*		mA
<b>LOAD CURRENT (SINK)</b>		-0.3	-0.5		*	*		mA
<b>SHORT-CIRCUIT CURRENT</b>	$V_{OUT} = 0$		30			*		mA
<b>POWER DISSIPATION</b>	No Load		15	21		*	*	mW
<b>TEMPERATURE VOLTAGE OUTPUT<sup>(7)</sup></b>			630			*		mV
<b>TEMPERATURE COEFFICIENT</b> of Temperature Pin Voltage -55°C to +125°C			2.1					$\text{mV}/^\circ\text{C}$
<b>TEMPERATURE RANGE</b> Specification REF02A, B, C		-40		+85	*		*	$^\circ\text{C}$

NOTES: (1)  $\Delta V_{OT}$  is defined as the absolute difference between the maximum output and the minimum output voltage over the specified temperature range expressed as a percentage of 5V:

$$\Delta V_O = \left| \frac{V_{MAX} - V_{MIN}}{5V} \right| \times 100$$

(2)  $\Delta V_{OT}$  specification applies trimmed to +5.000V or untrimmed.

(3)  $TCV_O$  is defined as  $\Delta V_{OT}$  divided by the temperature range.

(4) Line and load regulation specifications include the effect of self heating.

(5) Sample tested.

(6) 10k $\Omega$  potentiometer connected between  $V_{OUT}$  and ground with wiper connected to Trim pin. See figure on page 1.

(7) Pin 3 is insensitive to capacitive loading. The temperature voltage will be modified by 7mV for each  $\mu\text{A}$  of loading.

## ABSOLUTE MAXIMUM RATINGS

Input Voltage .....	+40V
Operating Temperature	
P, U .....	-40°C to +85°C
Storage Temperature Range	
P, U .....	-65°C to +125°
Output Short Circuit Duration (to Ground or $V_{IN}$ ) .....	Indefinite
Junction Temperature .....	-65°C to +150°
$\theta_{JA}$ P .....	120°C/W
U .....	80°C/W
Lead Temperature (soldering, 60s) .....	+300°C

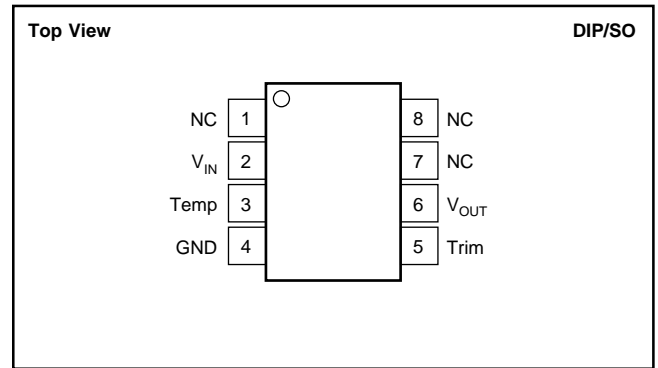


## ELECTROSTATIC DISCHARGE SENSITIVITY

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

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

## PIN CONFIGURATIONS



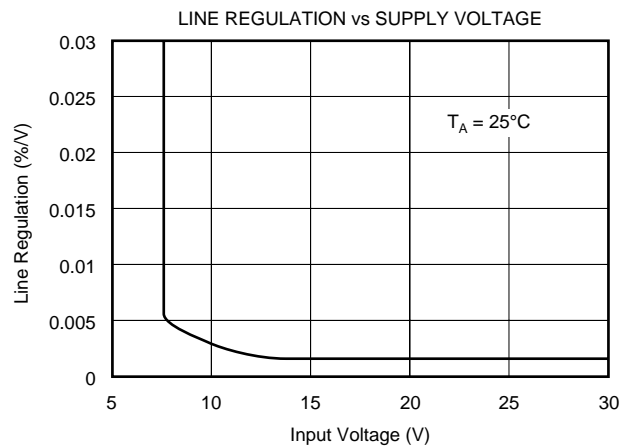
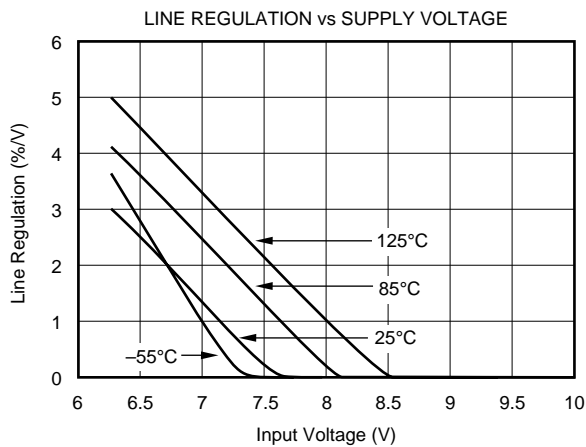
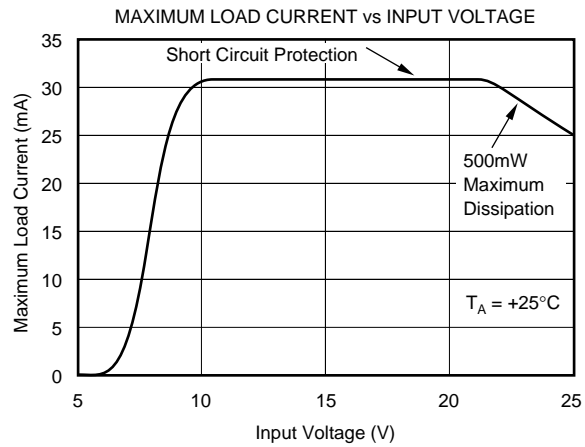
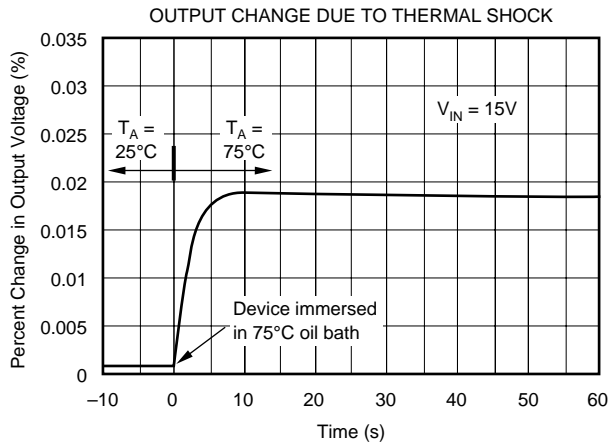
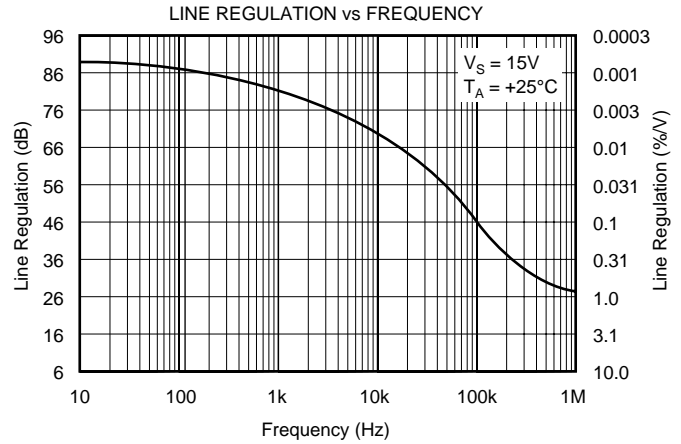
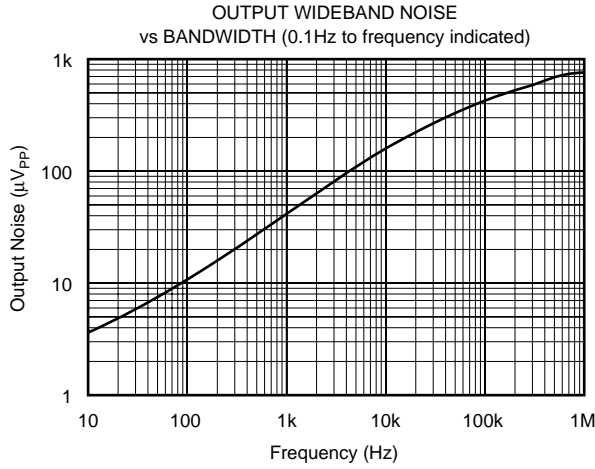
## PACKAGE/ORDERING INFORMATION<sup>(1)</sup>

PRODUCT	$V_{OUT}$ at 25°C	MAX DRIFT (ppm/°C)	PACKAGE	PACKAGE DRAWING DESIGNATOR	SPECIFICATION TEMPERATURE RANGE
REF02AU	5V±15mV	±15	SO-8	D	-40°C to +85°C
REF02BU	5V±10mV	±10	SO-8	D	-40°C to +85°C
REF02AP	5V±15mV	±15	DIP-8	P	-40°C to +85°C
REF02BP	5V±10mV	±10	DIP-8	P	-40°C to +85°C

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

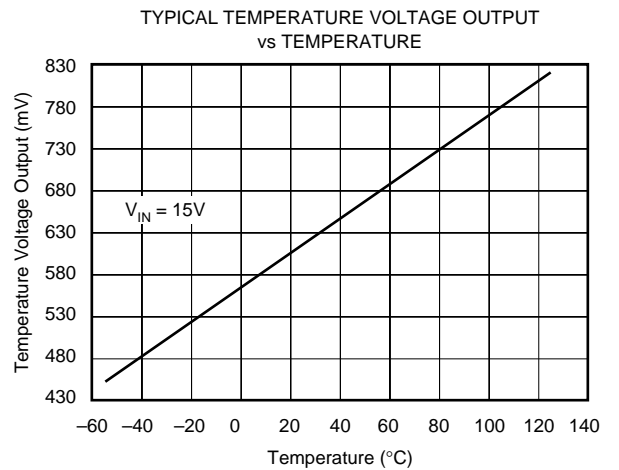
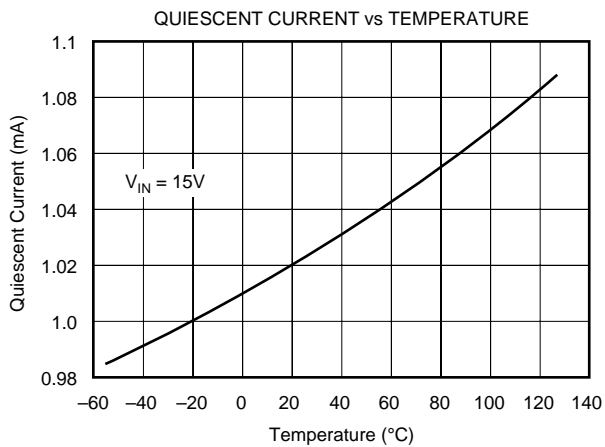
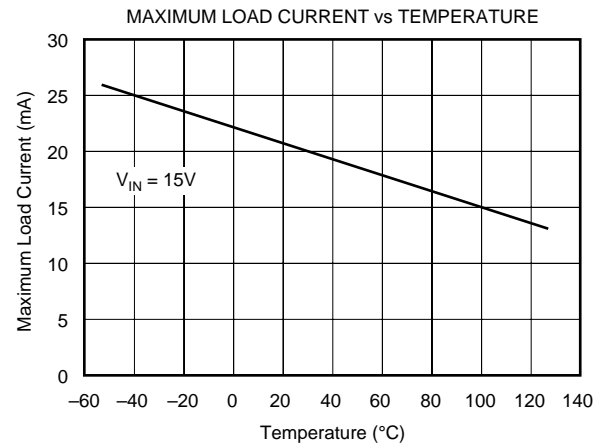
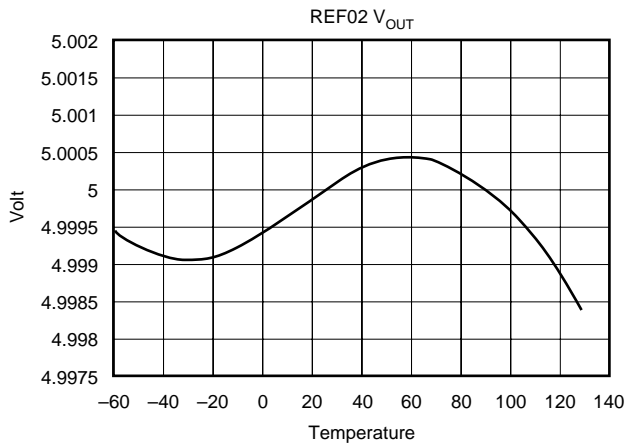
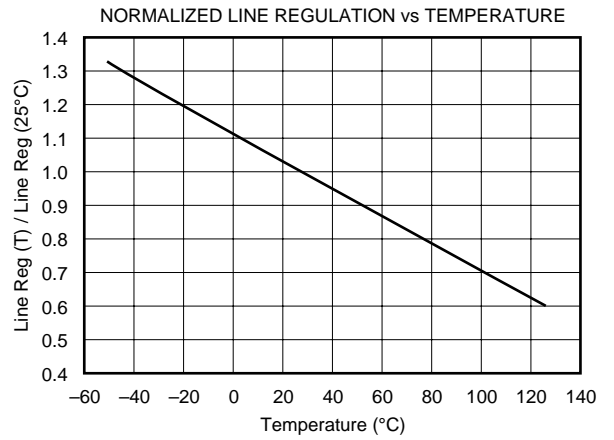
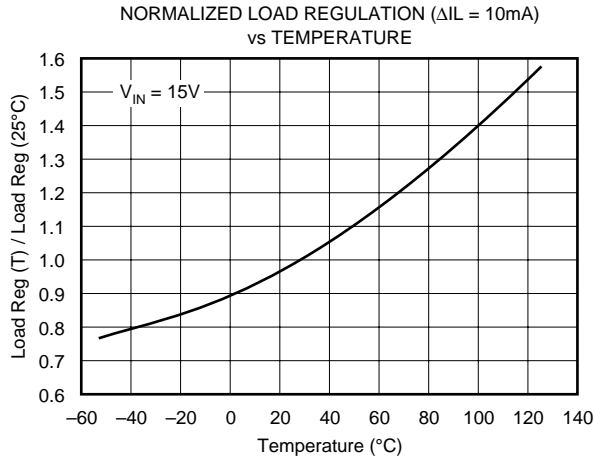
# TYPICAL PERFORMANCE CURVES

AT  $T_A = +25^\circ\text{C}$ , unless otherwise noted.



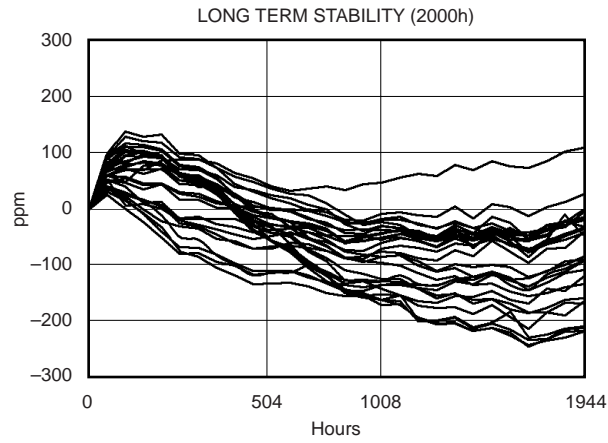
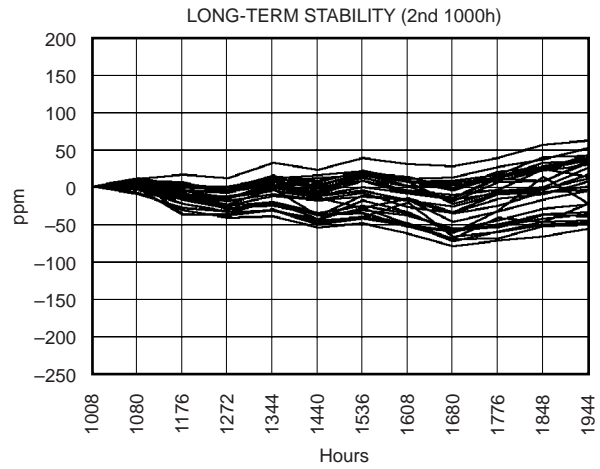
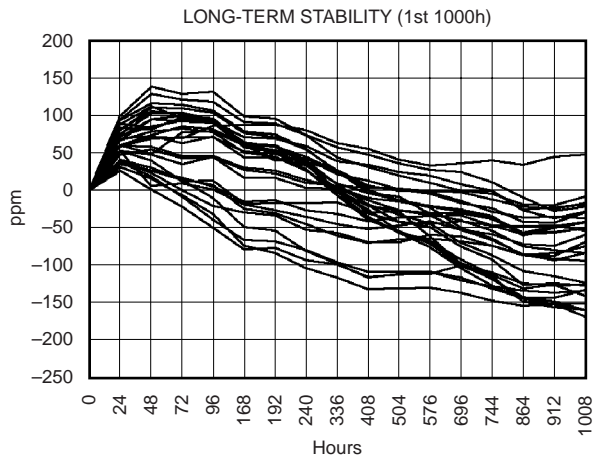
# TYPICAL PERFORMANCE CURVES (Cont.)

At  $T_A = +25^\circ\text{C}$ , unless otherwise noted.



# TYPICAL PERFORMANCE CURVES (Cont.)

At  $T_A = +25^\circ\text{C}$ , unless otherwise noted.



## OUTPUT ADJUSTMENT

The REF02 trim terminal can be used to adjust the voltage over a 5V  $\pm$ 150mV range. This feature allows the system designer to trim system errors by setting the reference to a voltage other than 5V, including 5.12V<sup>(1)</sup> for binary applications (see circuit on page 1).

Adjustment of the output does not significantly affect the temperature performance of the device. The temperature coefficient change is approximately 0.7ppm/ $^{\circ}$ C for 100mV of output adjustment.

NOTE: (1) 20mV LSB for 8-bit applications.

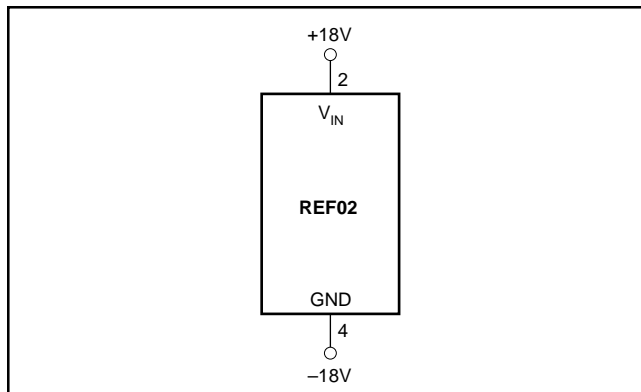


FIGURE 1. Burn-In Circuit.

## REFERENCE STACKING PROVIDES OUTSTANDING LINE REGULATION

By stacking two REF01s and one REF02, a systems designer can achieve 5V, 15V, and 25V outputs. One very important advantage of this circuit is the near-perfect line regulation at 5V and 15V outputs. This circuit can accept a 27V to 55V change to the input with less than the noise voltage as a change to the output voltage.  $R_B$ , a load bypass resistor, supplies current  $I_{SY}$  for the 15V regulator.

Any number of REF01s and REF02s can be stacked in this configuration. For example, if ten devices are stacked in this configuration, ten 5V or five 10V outputs are achieved. The line voltage may range from 100V to 130V. Care should be exercised to insure that the total load currents do not exceed the maximum usable current, which is typically 21mA.

## TYPICAL APPLICATIONS

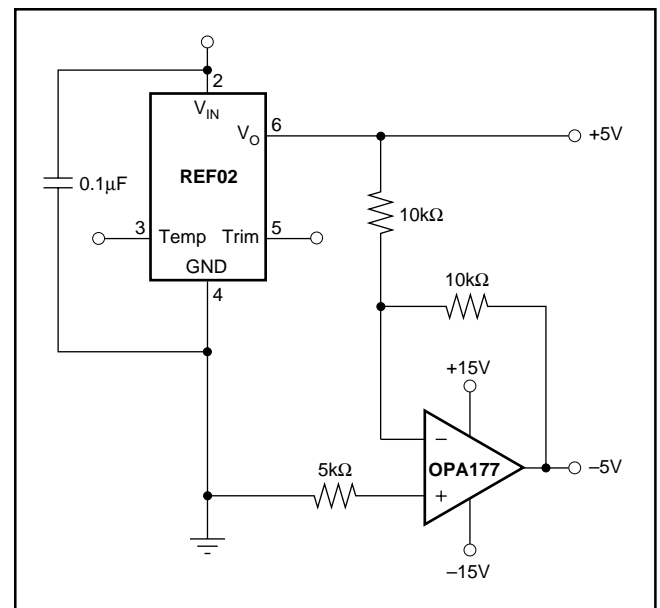


FIGURE 2.  $\pm$ 5V Precision Reference.

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
REF02AU	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 85	REF 02AU	<a href="#">Samples</a>
REF02AU/2K5	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 85	REF 02AU	<a href="#">Samples</a>
REF02BU	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 85	REF 02BU	<a href="#">Samples</a>
REF02BU/2K5	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 85	REF 02BU	<a href="#">Samples</a>

(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.

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

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

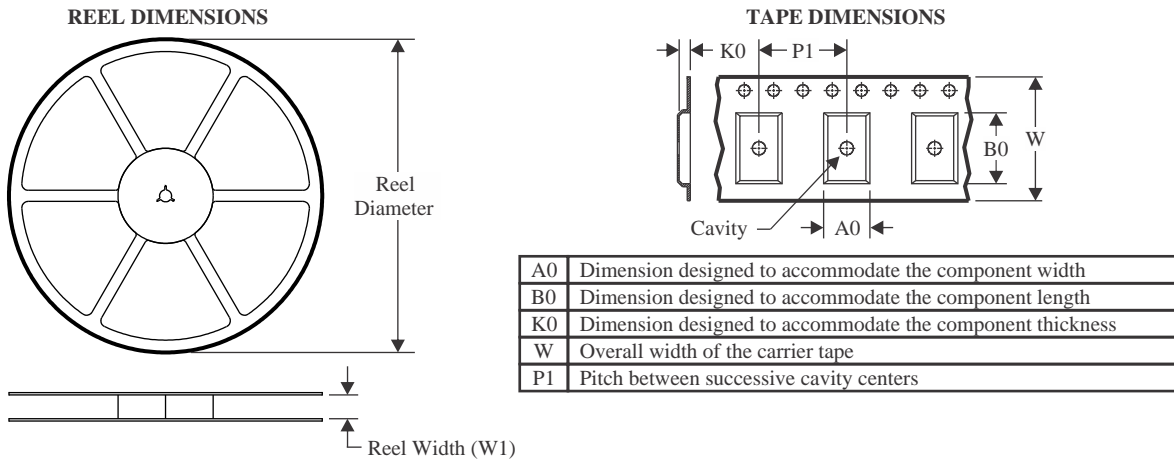
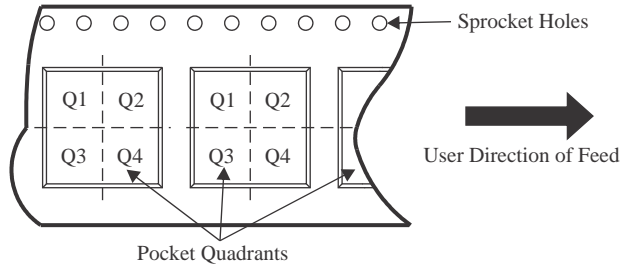
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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**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
REF02AU/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
REF02BU/2K5	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)
REF02AU/2K5	SOIC	D	8	2500	356.0	356.0	35.0
REF02BU/2K5	SOIC	D	8	2500	356.0	356.0	35.0

**TUBE**


\*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
REF02AU	D	SOIC	8	75	506.6	8	3940	4.32
REF02BU	D	SOIC	8	75	506.6	8	3940	4.32



D0008A

# PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed  $.006$  [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.

# EXAMPLE BOARD LAYOUT

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE  
 EXPOSED METAL SHOWN  
 SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE  
BASED ON .005 INCH [0.125 MM] THICK STENCIL  
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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