

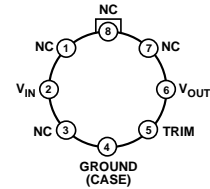
### FEATURES

- 5 V output:  $\pm 0.3\%$  maximum**
- Temperature voltage output:  $1.96 \text{ mV}/^\circ\text{C}$**
- Adjustment range:  $\pm 3\%$  minimum**
- Excellent temperature stability:  $8.5 \text{ ppm}/^\circ\text{C}$  maximum**
- Low noise:  $15 \mu\text{V p-p}$  maximum**
- Low supply current:  $1.4 \text{ mA}$  maximum**
- Wide input voltage range:  $7 \text{ V}$  to  $40 \text{ V}$**
- High load-driving capability:  $10 \text{ mA}$**
- No external components**
- Short-circuit proof**

### GENERAL DESCRIPTION

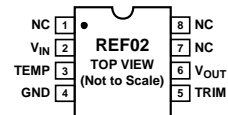
The REF02 precision voltage reference provides a stable 5 V output that can be adjusted over a  $\pm 6\%$  range with minimal effect on temperature stability. Single-supply operation over an input voltage range of 7 V to 40 V, low current drain of 1 mA, and excellent temperature stability are achieved with an improved band gap design. Low cost, low noise, and low power make the REF02 an excellent choice whenever a stable voltage reference is required. Applications include DACs and ADCs, portable instrumentation, and digital voltmeters. The versatility of the REF02 is enhanced by its use as a monolithic temperature transducer. For new designs, refer to the ADR02.

### PIN CONFIGURATIONS



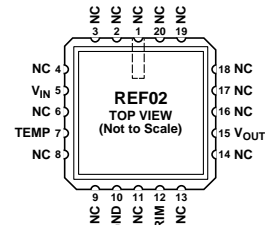
NC = NO CONNECT. DO NOT CONNECT ANYTHING ON THESE PINS. SOME OF THEM ARE RESERVED FOR FACTORY TESTING PURPOSES.

Figure 1. 8-Lead TO-99 (J-Suffix)



NC = NO CONNECT. DO NOT CONNECT ANYTHING ON THESE PINS. SOME OF THEM ARE RESERVED FOR FACTORY TESTING PURPOSES.

Figure 2. 8-Lead PDIP (P-Suffix), 8-Lead CERDIP (Z-Suffix) and 8-Lead SOIC (S-Suffix)



NC = NO CONNECT. DO NOT CONNECT ANYTHING ON THESE PINS. SOME OF THEM ARE RESERVED FOR FACTORY TESTING PURPOSES.

Figure 3. 20-Terminal LCC (RC-Suffix)

REF02 OPTION	R9	R11	R12
883C PRODUCT	18k $\Omega$	2k $\Omega$	6.1k $\Omega$
P, S, J, Z PACKAGES	18k $\Omega$	4.5k $\Omega$	15k $\Omega$

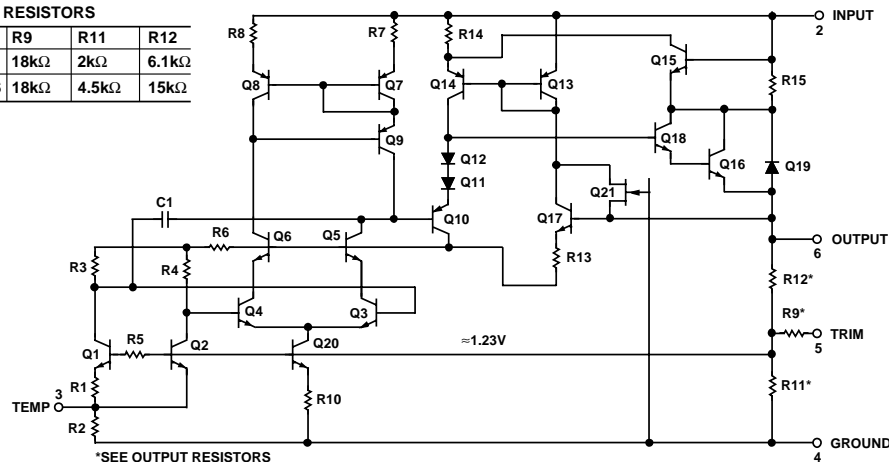


Figure 4. Simplified Schematic

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# SPECIFICATIONS

## ELECTRICAL SPECIFICATIONS

@  $V_{IN} = 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise noted.

Table 1.

Parameter	Symbol	Conditions	REF02A/REF02E			REF02/REF02H			Unit
			Min	Typ	Max	Min	Typ	Max	
Output Voltage	$V_O$	$I_L = 0\text{ mA}$	4.985	5.000	5.015	4.975	5.000	5.025	V
Output Adjustment Range	$\Delta V_{TRIM}$	$R_P = 10\text{ k}\Omega$	$\pm 3$	$\pm 6$		$\pm 3$	$\pm 6$		%
Output Voltage Noise <sup>1</sup>	$e_n$ p-p	0.1 Hz to 10 Hz							
P, Z, and S Packages				15			15		$\mu\text{V p-p}$
J Package				20			20		$\mu\text{V p-p}$
883 Parts				10	15		10	15	$\mu\text{V p-p}$
Line Regulation <sup>2</sup>		$V_{IN} = 8\text{ V to }40\text{ V}$		0.006	0.010		0.006	0.010	%/V
Load Regulation <sup>2</sup>		$I_L = 0\text{ mA to }10\text{ mA}$		0.005	0.010		0.006	0.010	%/mA
Turn-On Settling Time <sup>1</sup>	$t_{ON}$	To $\pm 0.1\%$ of final value		5			5		$\mu\text{s}$
Quiescent Supply Current	$I_{SY}$	No load		1.0	1.4		1.0	1.4	mA
Load Current	$I_L$		10			10			mA
Sink Current <sup>3</sup>	$I_S$		-0.3	-0.5		-0.3	-0.5		mA
Short-Circuit Current	$I_{SC}$	$V_O = 0$		30			30		mA
Temperature Voltage Output <sup>4</sup>									
883C Product	$V_T$			630			630		mV
P, S, J, and Z Packages	$V_T$			550			550		mV

<sup>1</sup> Guaranteed by design.

<sup>2</sup> Line and load regulation specifications include the effect of self-heating.

<sup>3</sup> During sink current test, the device meets the output voltage specified.

<sup>4</sup> Limit current in or out of Pin 3 to 50 nA and capacitance on Pin 3 to 30 pF.

# REF02

@  $V_{IN} = 15\text{ V}$ ,  $-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$  for REF02A and REF02;  $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$  for REF02E and REF02H;  $I_L = 0\text{ mA}$ , unless otherwise noted.

**Table 2.**

Parameter	Symbol	Conditions	REF02A/REF02E			REF02/REF02H			Unit
			Min	Typ	Max	Min	Typ	Max	
Output Voltage Change with Temperature <sup>1,2</sup>	$\Delta V_{OT}$	$0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ $-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$		0.02	0.06		0.07	0.17	%
Output Voltage Temperature Coefficient <sup>3</sup>	$TCV_O$			0.06	0.15		0.18	0.45	%
Change in $V_O$ Temperature Coefficient with Output Adjustment		$R_P = 10\text{ k}\Omega$		3	8.5		10	25	ppm/ $^{\circ}\text{C}$
Line Regulation $V_{IN} = 8\text{ V to }40\text{ V}^4$		$0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ $-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$		0.7			0.7		ppm/%
Load Regulation $I_L = 0\text{ mA to }8\text{ mA}^4$		$0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ $-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$		0.007	0.012		0.007	0.012	%/V
Temperature Voltage Output Temperature Coefficient <sup>5</sup> 883C Product P, S, J, and Z Packages	$TCV_T$			0.009	0.015		0.009	0.015	%/V
				0.006	0.010		0.007	0.012	%/mA
				0.007	0.012		0.009	0.015	%/mA
				2.10			2.10		mV/ $^{\circ}\text{C}$
				1.96			1.96		mV/ $^{\circ}\text{C}$

<sup>1</sup>  $\Delta V_{OT}$  is defined as the absolute difference between the maximum output voltage and the minimum output voltage over the specified temperature range expressed as a percentage of 5 V.

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

<sup>2</sup>  $\Delta V_{OT}$  specification applies trimmed to 5,000 V or untrimmed.

<sup>3</sup>  $TCV_O$  is defined as  $\Delta V_{OT}$  divided by the temperature range.

$$TCV_O = \frac{\Delta V_{OT}}{70^{\circ}\text{C}}$$

<sup>4</sup> Line and load regulation specifications include the effect of self-heating.

<sup>5</sup> Limit current in or out of Pin 3 to 50 nA and capacitance on Pin 3 to 30 pF.

@  $V_{IN} = 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise noted.

**Table 3.**

Parameter	Symbol	Conditions	REF02C			REF02D			Unit
			Min	Typ	Max	Min	Typ	Max	
Output Voltage	$V_O$	$I_L = 0\text{ mA}$	4.950	5.000	5.050	4.900	5.000	5.100	V
Output Adjustment Range	$\Delta V_{TRIM}$	$R_p = 10\text{ k}\Omega$	$\pm 2.7$	$\pm 6.0$		$\pm 2.0$	$\pm 6.0$		%
Output Voltage Noise <sup>1</sup> P, Z, and S Packages	$e_n$ p-p	0.1 Hz to 10 Hz		15					$\mu\text{V p-p}$
J Package				20			15		$\mu\text{V p-p}$
883 Parts				12	18		20		$\mu\text{V p-p}$
Line Regulation <sup>2</sup>		$V_{IN} = 8\text{ V to }40\text{ V}$		0.009	0.015		0.010	0.04	%/V
Load Regulation <sup>2</sup>		$I_L = 0\text{ mA to }8\text{ mA}$		0.006	0.015				%/mA
		$I_L = 0\text{ mA to }4\text{ mA}$					0.015	0.04	%/mA
Turn-On Settling Time <sup>1</sup>	$t_{ON}$	To $\pm 0.1\%$ of final value		5			5		$\mu\text{s}$
Quiescent Supply Current	$I_{SY}$	No load		1.0	1.6		1.0	2.0	mA
Load Current	$I_L$		8			8			mA
Sink Current <sup>3</sup>	$I_S$		-0.3	-0.5		-0.3	-0.5		mA
Short-Circuit Current	$I_{SC}$	$V_O = 0$		30			30		mA
Temperature Voltage Output <sup>4</sup> 883C Product	$V_T$			630			630		mV
P, S, J, and Z Packages	$V_T$			550			550		mV

<sup>1</sup> Guaranteed by design.

<sup>2</sup> Line and load regulation specifications include the effect of self-heating.

<sup>3</sup> During sink current test, the device meets the output voltage specified.

<sup>4</sup> Limit current in or out of Pin 3 to 50 nA and capacitance on Pin 3 to 30 pF.

# REF02

@  $V_{IN} = 15\text{ V}$ ,  $I_L = 0\text{ mA}$ ,  $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$  for REF02CJ, REF02CZ, and REF02DP; and  $-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$  for REF02CP and REF02CS, unless otherwise noted.

**Table 4.**

Parameter	Symbol	Conditions	REF02C			REF02D			Unit
			Min	Typ	Max	Min	Typ	Max	
Output Voltage Change with Temperature <sup>1,2</sup>	$\Delta V_{OT}$			0.14	0.45		0.49	1.7	%
Output Voltage Temperature Coefficient <sup>3</sup>	$TCV_o$	$R_F = 10\text{ k}\Omega$		20	65		70	250	ppm/ $^\circ\text{C}$
Change in $V_o$ Temperature Coefficient with Output Adjustment				0.7		0.7			ppm/%
Line Regulation <sup>4</sup>		$V_{IN} = 8\text{ V to }40\text{ V}$ $I_L = 0\text{ mA to }5\text{ mA}$		0.011	0.018		0.012	0.05	%/V
Load Regulation <sup>4</sup>				0.008	0.018		0.016	0.05	%/mA
Temperature Voltage Output Temperature Coefficient <sup>5</sup>			$TCV_T$						
883C Product				2.10			2.10		mV/ $^\circ\text{C}$
P, S, J, and Z Packages				1.96			1.96		mV/ $^\circ\text{C}$

<sup>1</sup>  $\Delta V_{OT}$  is defined as the absolute difference between the maximum output voltage and the minimum output voltage over the specified temperature range expressed as a percentage of 5 V.

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

<sup>2</sup>  $\Delta V_{OT}$  specification applies trimmed to 5,000 V or untrimmed.

<sup>3</sup>  $TCV_o$  is defined as  $\Delta V_{OT}$  divided by the temperature range.

$$TCV_o = \frac{\Delta V_{OT}}{70^\circ\text{C}}$$

<sup>4</sup> Line and load regulation specifications include the effect of self-heating.

<sup>5</sup> Limit current in or out of Pin 3 to 50 nA and capacitance on Pin 3 to 30 pF.

## ABSOLUTE MAXIMUM RATINGS

Table 5.

Parameter	Rating <sup>1</sup>
Input Voltage	40 V
Output Short-Circuit Duration to Ground or $V_{IN}$	Indefinite
Storage Temperature Range	
J, RC, and Z Packages	–65°C to +150°C
P Package	–65°C to +125°C
Operating Temperature Range	
REF02A, REF02J, REF02RC	–55°C to +125°C
REF02CJ, REF02CZ	0°C to 70°C
REF02CP, REF02CS, REF02E, and REF02H	–40°C to +85°C
Lead Temperature Range (Soldering 10 sec)	300°C

<sup>1</sup> Absolute maximum ratings apply to both DICE packaged parts, unless otherwise noted.

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## THERMAL RESISTANCE

Table 6.

Package Type	$\theta_{JA}$ <sup>1</sup>	$\theta_{JC}$	Unit
TO-99 (J)	170	24	°C/W
8-Lead CERDIP (Z)	162	26	°C/W
8-Lead PDIP (P)	110	50	°C/W
20-Terminal Ceramic LCC (RC)	120	40	°C/W
8-Lead SOIC (S)	160	44	°C/W

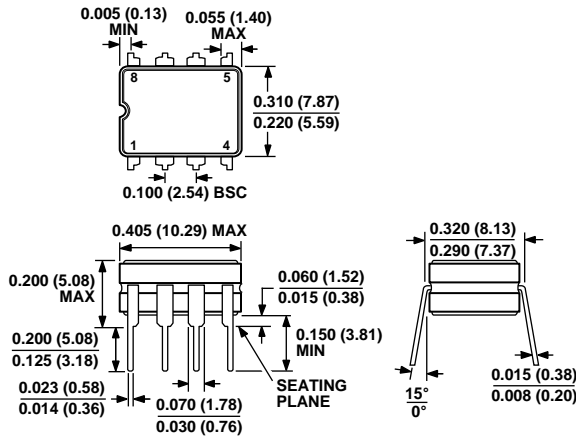
<sup>1</sup>  $\theta_{JA}$  is specified for worst-case mounting conditions; device in socket for TO, CERDIP, PDIP, and LCC packages; and device soldered to printed circuit board for SOIC package.

## ESD CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

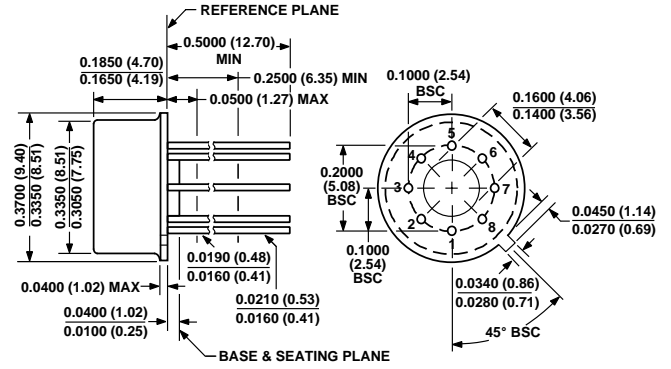


# OUTLINE DIMENSIONS



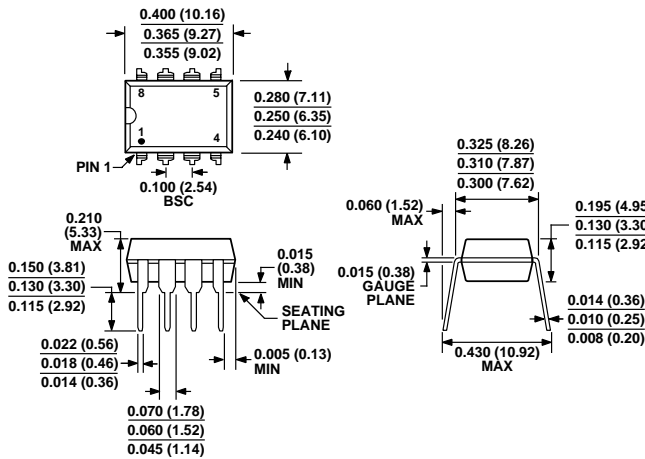
CONTROLLING DIMENSIONS ARE IN INCHES; MILLIMETER DIMENSIONS (IN PARENTHESES) ARE ROUNDED-OFF INCH EQUIVALENTS FOR REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.

Figure 27. 8-Lead Ceramic Dual In-Line Package [CERDIP]  
Z-Suffix  
(Q-8)  
Dimensions shown in inches and (millimeters)



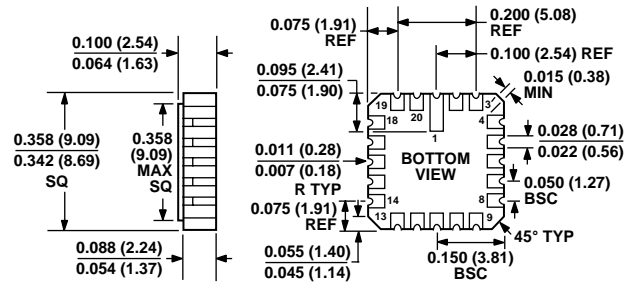
COMPLIANT TO JEDEC STANDARDS MO-002-AK  
CONTROLLING DIMENSIONS ARE IN INCHES; MILLIMETER DIMENSIONS (IN PARENTHESES) ARE ROUNDED-OFF INCH EQUIVALENTS FOR REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.

Figure 29. 8-Lead Metal Header Package [TO-99]  
J-Suffix  
(H-08)  
Dimensions shown in inches and (millimeters)



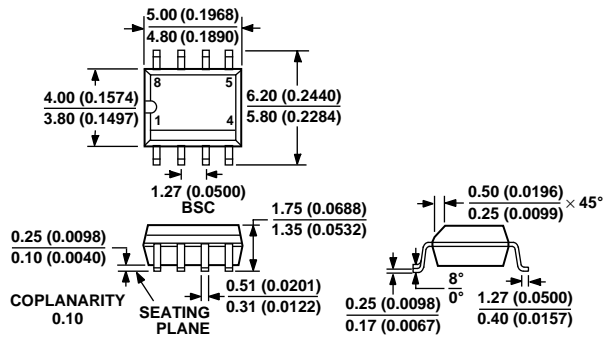
COMPLIANT TO JEDEC STANDARDS MS-001-BA  
CONTROLLING DIMENSIONS ARE IN INCHES; MILLIMETER DIMENSIONS (IN PARENTHESES) ARE ROUNDED-OFF INCH EQUIVALENTS FOR REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN. CORNER LEADS MAY BE CONFIGURED AS WHOLE OR HALF LEADS.

Figure 28. 8-Lead Plastic Dual In-Line Package [PDIP]  
Narrow Body  
P-Suffix  
(N-8)  
Dimensions shown in inches and (millimeters)



CONTROLLING DIMENSIONS ARE IN INCHES; MILLIMETER DIMENSIONS (IN PARENTHESES) ARE ROUNDED-OFF INCH EQUIVALENTS FOR REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.

Figure 30. 20-Terminal Ceramic Leadless Chip Carrier [LCC]  
RC-Suffix  
(E-20A)  
Dimensions shown in inches and (millimeters)



COMPLIANT TO JEDEC STANDARDS MS-012-AA  
 CONTROLLING DIMENSIONS ARE IN MILLIMETERS; INCH DIMENSIONS  
 (IN PARENTHESES) ARE ROUNDED-OFF MILLIMETER EQUIVALENTS FOR  
 REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.

Figure 31. 8-Lead Standard Small Outline Package [SOIC]  
 Narrow Body  
 S-Suffix  
 (R-8)  
 Dimensions shown in millimeters and (inches)



## ORDERING GUIDE

Model	$T_A = 25^\circ\text{C}$ $\Delta V_{os} \text{ Max (mV)}$	Temperature Range	Package Description	Package Option
REF02AJ/883C <sup>1</sup>	±15	-55°C to +125°C	8-Lead TO-99	J-Suffix (H-08)
REF02AZ	±15	-55°C to +125°C	8-Lead CERDIP	Z-Suffix (Q-8)
REF02AZ/883C <sup>1</sup>	±15	-55°C to +125°C	8-Lead CERDIP	Z-Suffix (Q-8)
REF02CJ	±50	0°C to 70°C	8-Lead TO-99	J-Suffix (H-08)
REF02CP	±50	-40°C to +85°C	8-Lead PDIP	P-Suffix (N-8)
REF02CPZ <sup>2</sup>	±50	-40°C to +85°C	8-Lead PDIP	P-Suffix (N-8)
REF02CS	±50	-40°C to +85°C	8-Lead SOIC	S-Suffix (R-8)
REF02CS-REEL	±50	-40°C to +85°C	8-Lead SOIC	S-Suffix (R-8)
REF02CS-REEL7	±50	-40°C to +85°C	8-Lead SOIC	S-Suffix (R-8)
REF02CSZ <sup>2</sup>	±50	-40°C to +85°C	8-Lead SOIC	S-Suffix (R-8)
REF02CSZ-REEL <sup>2</sup>	±50	-40°C to +85°C	8-Lead SOIC	S-Suffix (R-8)
REF02CSZ-REEL7 <sup>2</sup>	±50	-40°C to +85°C	8-Lead SOIC	S-Suffix (R-8)
REF02CZ	±50	0°C to 70°C	8-Lead CERDIP	Z-Suffix (Q-8)
REF02DP	±100	0°C to 70°C	8-Lead PDIP	P-Suffix (N-8)
REF02DPZ <sup>2</sup>	±100	0°C to 70°C	8-Lead PDIP	P-Suffix (N-8)
REF02EJ	±15	-40°C to +85°C	8-Lead TO-99	J-Suffix (H-08)
REF02EZ	±15	-40°C to +85°C	8-Lead CERDIP	Z-Suffix (Q-8)
REF02J	±25	-55°C to +125°C	8-Lead TO-99	J-Suffix (H-08)
REF02HJ	±25	-40°C to +85°C	8-Lead TO-99	J-Suffix (H-08)
REF02HZ	±25	-40°C to +85°C	8-Lead CERDIP	Z-Suffix (Q-8)
REF02HP	±25	-40°C to +85°C	8-Lead PDIP	P-Suffix (N-8)
REF02HPZ <sup>2</sup>	±25	-40°C to +85°C	8-Lead PDIP	P-Suffix (N-8)
REF02HS	±25	-40°C to +85°C	8-Lead SOIC	S-Suffix (R-8)
REF02HSZ <sup>2</sup>	±25	-40°C to +85°C	8-Lead SOIC	S-Suffix (R-8)
REF02RC/883 <sup>1</sup>	±25	-55°C to +125°C	20-Lead LCC	RC-Suffix (E-20A)
REF02Z	±25	-55°C to +125°C	8-Lead CERDIP	Z-Suffix (Q-8)

<sup>1</sup> Consult sales for 883 data sheet.<sup>2</sup> Z = Pb-free part.