

## REF19x Series

### FEATURES

- Initial accuracy:  $\pm 2$  mV maximum**
- Temperature coefficient: 5 ppm/ $^{\circ}$ C maximum**
- Low supply current: 45  $\mu$ A maximum**
- Sleep mode: 15  $\mu$ A maximum**
- Low dropout voltage**
- Load regulation: 4 ppm/mA**
- Line regulation: 4 ppm/V**
- High output current: 30 mA**
- Short-circuit protection**

### APPLICATIONS

- Portable instruments
- ADCs and DACs
- Smart sensors
- Solar powered applications
- Loop-current-powered instruments

### GENERAL DESCRIPTION

The REF19x series precision band gap voltage references use a patented temperature drift curvature correction circuit and laser trimming of highly stable, thin-film resistors to achieve a very low temperature coefficient and high initial accuracy.

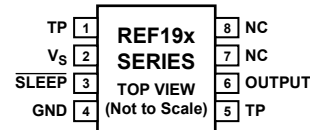
The REF19x series is made up of micropower, low dropout voltage (LDV) devices, providing stable output voltage from supplies as low as 100 mV above the output voltage and consuming less than 45  $\mu$ A of supply current. In sleep mode, which is enabled by applying a low TTL or CMOS level to the SLEEP pin, the output is turned off and supply current is further reduced to less than 15  $\mu$ A.

The REF19x series references are specified over the extended industrial temperature range ( $-40^{\circ}$ C to  $+85^{\circ}$ C) with typical performance specifications over  $-40^{\circ}$ C to  $+125^{\circ}$ C for applications, such as automotive.

All electrical grades are available in an 8-lead SOIC package; the PDIP and TSSOP packages are available only in the lowest electrical grade.

### TEST PINS

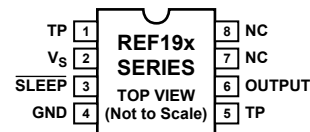
Test Pin 1 and Test Pin 5 are reserved for in-package Zener zap. To achieve the highest level of accuracy at the output, the Zener zapping technique is used to trim the output voltage. Because each unit may require a different amount of adjustment, the resistance value at the test pins varies widely from pin to pin and from part to part. The user should leave Pin 1 and Pin 5 unconnected.



- NOTES
1. NC = NO CONNECT.
  2. TP PINS ARE FACTORY TEST POINTS, NO USER CONNECTION.

00371-001

Figure 1. 8-Lead SOIC\_N and TSSOP Pin Configuration (S Suffix and RU Suffix)



- NOTES
1. NC = NO CONNECT.
  2. TP PINS ARE FACTORY TEST POINTS, NO USER CONNECTION.

00371-002

Figure 2. 8-Lead PDIP Pin Configuration (P Suffix)

Table 1. Nominal Output Voltage

Part Number	Nominal Output Voltage (V)
REF191	2.048
REF192	2.50
REF193	3.00
REF194	4.50
REF195	5.00
REF196	3.30
REF198	4.096

# REF19x Series

## SPECIFICATIONS

### ELECTRICAL CHARACTERISTICS—REF191 @ $T_A = 25^\circ\text{C}$

@  $V_S = 3.3\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise noted.

Table 2.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
INITIAL ACCURACY <sup>1</sup>	$V_O$					
E Grade		$I_{OUT} = 0\text{ mA}$	2.046	2.048	2.050	V
F Grade			2.043		2.053	V
G Grade			2.038		2.058	V
LINE REGULATION <sup>2</sup>	$\Delta V_O / \Delta V_{IN}$					
E Grade		$3.0\text{ V} \leq V_S \leq 15\text{ V}$ , $I_{OUT} = 0\text{ mA}$		2	4	ppm/V
F and G Grades				4	8	ppm/V
LOAD REGULATION <sup>2</sup>	$\Delta V_O / \Delta V_{LOAD}$					
E Grade		$V_S = 5.0\text{ V}$ , $0\text{ mA} \leq I_{OUT} \leq 30\text{ mA}$		4	10	ppm/mA
F and G Grades				6	15	ppm/mA
DROPOUT VOLTAGE	$V_S - V_O$					
		$V_S = 3.15\text{ V}$ , $I_{LOAD} = 2\text{ mA}$			0.95	V
		$V_S = 3.3\text{ V}$ , $I_{LOAD} = 10\text{ mA}$			1.25	V
		$V_S = 3.6\text{ V}$ , $I_{LOAD} = 30\text{ mA}$			1.55	V
LONG-TERM STABILITY <sup>3</sup>	$DV_O$	1000 hours @ $125^\circ\text{C}$		1.2		mV
NOISE VOLTAGE	$e_N$	0.1 Hz to 10 Hz		20		$\mu\text{V p-p}$

<sup>1</sup> Initial accuracy includes temperature hysteresis effect.

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

<sup>3</sup> Long-term stability specification is noncumulative. The drift in subsequent 1000-hour periods is significantly lower than in the first 1000-hour period.

**ELECTRICAL CHARACTERISTICS—REF191 @  $-40^{\circ}\text{C} \leq +85^{\circ}\text{C}$** 

@  $V_S = 3.3\text{ V}$ ,  $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ , unless otherwise noted.

**Table 3.**

Parameter	Symbol	Condition	Min	Typ	Max	Unit			
TEMPERATURE COEFFICIENT <sup>1, 2</sup>	$TCV_O/^{\circ}\text{C}$	$I_{\text{OUT}} = 0\text{ mA}$							
E Grade							2	5	ppm/ $^{\circ}\text{C}$
F Grade							5	10	ppm/ $^{\circ}\text{C}$
G Grade <sup>3</sup>						10	25	ppm/ $^{\circ}\text{C}$	
LINE REGULATION <sup>4</sup>	$\Delta V_O/\Delta V_{\text{IN}}$	$3.0\text{ V} \leq V_S \leq 15\text{ V}$ , $I_{\text{OUT}} = 0\text{ mA}$							
E Grade							5	10	ppm/V
F and G Grades						10	20	ppm/V	
LOAD REGULATION <sup>4</sup>	$\Delta V_O/\Delta V_{\text{LOAD}}$	$V_S = 5.0\text{ V}$ , $0\text{ mA} \leq I_{\text{OUT}} \leq 25\text{ mA}$							
E Grade							5	15	ppm/mA
F and G Grades						10	20	ppm/mA	
DROPOUT VOLTAGE	$V_S - V_O$	$V_S = 3.15\text{ V}$ , $I_{\text{LOAD}} = 2\text{ mA}$ $V_S = 3.3\text{ V}$ , $I_{\text{LOAD}} = 10\text{ mA}$ $V_S = 3.6\text{ V}$ , $I_{\text{LOAD}} = 25\text{ mA}$							
							0.95	V	
							1.25	V	
						1.55	V		
SLEEP PIN									
Logic High Input Voltage	$V_H$		2.4			V			
Logic High Input Current	$I_H$				-8	$\mu\text{A}$			
Logic Low Input Voltage	$V_L$				0.8	V			
Logic Low Input Current	$I_L$				-8	$\mu\text{A}$			
SUPPLY CURRENT		No load				45	$\mu\text{A}$		
Sleep Mode		No load				15	$\mu\text{A}$		

<sup>1</sup> For proper operation, a 1  $\mu\text{F}$  capacitor is required between the output pin and the GND pin of the device.

<sup>2</sup>  $TCV_O$  is defined as the ratio of output change with temperature variation to the specified temperature range expressed in ppm/ $^{\circ}\text{C}$ .

$$TCV_O = (V_{\text{MAX}} - V_{\text{MIN}})/V_O(T_{\text{MAX}} - T_{\text{MIN}})$$

<sup>3</sup> Guaranteed by characterization.

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

# REF19x Series

## ELECTRICAL CHARACTERISTICS—REF191 @ $-40^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$

@  $V_S = 3.3\text{ V}$ ,  $-40^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$ , unless otherwise noted.

Table 4.

Parameter	Symbol	Condition	Min	Typ	Max	Unit		
TEMPERATURE COEFFICIENT <sup>1, 2</sup>	TCV <sub>O</sub> /°C	I <sub>OUT</sub> = 0 mA						
E Grade							2	ppm/°C
F Grade							5	ppm/°C
G Grade <sup>3</sup>						10	ppm/°C	
LINE REGULATION <sup>4</sup>	ΔV <sub>O</sub> /ΔV <sub>IN</sub>	3.0 V ≤ V <sub>S</sub> ≤ 15 V, I <sub>OUT</sub> = 0 mA						
E Grade							10	ppm/V
F and G Grades						20	ppm/V	
LOAD REGULATION <sup>4</sup>	ΔV <sub>O</sub> /ΔV <sub>LOAD</sub>	V <sub>S</sub> = 5.0 V, 0 mA ≤ I <sub>OUT</sub> ≤ 20 mA						
E Grade							10	ppm/mA
F and G Grades						20	ppm/mA	
DROPOUT VOLTAGE	V <sub>S</sub> – V <sub>O</sub>	V <sub>S</sub> = 3.3 V, I <sub>LOAD</sub> = 10 mA				1.25	V	
		V <sub>S</sub> = 3.6 V, I <sub>LOAD</sub> = 20 mA				1.55	V	

<sup>1</sup> For proper operation, a 1 μF capacitor is required between the output pin and the GND pin of the device.

<sup>2</sup> TCV<sub>O</sub> is defined as the ratio of output change with temperature variation to the specified temperature range expressed in ppm/°C.

$$TCV_O = (V_{MAX} - V_{MIN}) / V_O (T_{MAX} - T_{MIN})$$

<sup>3</sup> Guaranteed by characterization.

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

## ELECTRICAL CHARACTERISTICS—REF192 @ T<sub>A</sub> = 25°C

@ V<sub>S</sub> = 3.3 V, T<sub>A</sub> = 25°C, unless otherwise noted.

Table 5.

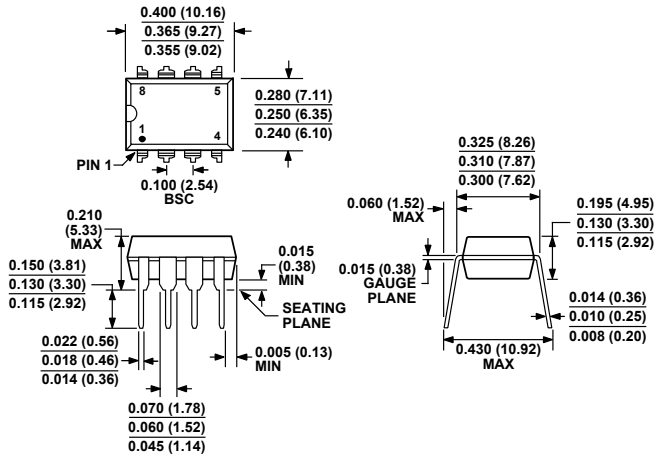
Parameter	Symbol	Condition	Min	Typ	Max	Unit				
INITIAL ACCURACY <sup>1</sup>	V <sub>O</sub>	I <sub>OUT</sub> = 0 mA								
E Grade							2.498	2.500	2.502	V
F Grade							2.495		2.505	V
G Grade					2.490	2.510	V			
LINE REGULATION <sup>2</sup>	ΔV <sub>O</sub> /ΔV <sub>IN</sub>	3.0 V ≤ V <sub>S</sub> ≤ 15 V, I <sub>OUT</sub> = 0 mA								
E Grade							2	4	ppm/V	
F and G Grades						4	8	ppm/V		
LOAD REGULATION <sup>2</sup>	ΔV <sub>O</sub> /ΔV <sub>LOAD</sub>	V <sub>S</sub> = 5.0 V, 0 mA ≤ I <sub>OUT</sub> ≤ 30 mA								
E Grade							4	10	ppm/mA	
F and G Grades						6	15	ppm/mA		
DROPOUT VOLTAGE	V <sub>S</sub> – V <sub>O</sub>	V <sub>S</sub> = 3.5 V, I <sub>LOAD</sub> = 10 mA				1.00	V			
		V <sub>S</sub> = 3.9 V, I <sub>LOAD</sub> = 30 mA				1.40	V			
LONG-TERM STABILITY <sup>3</sup>	DV <sub>O</sub>	1000 hours @ 125°C		1.2		mV				
NOISE VOLTAGE	e <sub>N</sub>	0.1 Hz to 10 Hz		25		μV p-p				

<sup>1</sup> Initial accuracy includes temperature hysteresis effect.

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

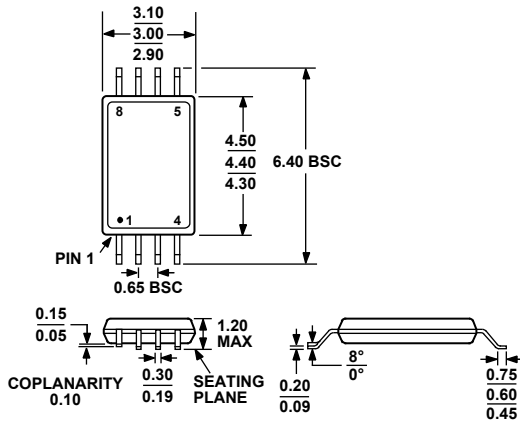
<sup>3</sup> Long-term stability specification is noncumulative. The drift in subsequent 1000-hour periods is significantly lower than in the first 1000-hour period.

## OUTLINE DIMENSIONS



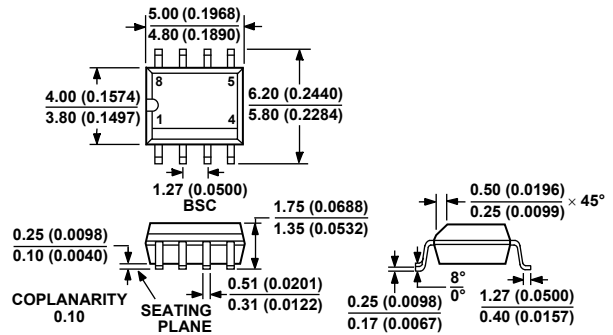
COMPLIANT TO JEDEC STANDARDS MS-001-BA  
 CONTROLLING DIMENSIONS ARE IN INCHES; MILLIMETER DIMENSIONS (IN PARENTHESES) ARE ROUNDED-OFF INCH EQUIVALENTS FOR REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN. CORNER LEADS MAY BE CONFIGURED AS WHOLE OR HALF LEADS.

Figure 32. 8-Lead Plastic Dual In-Line Package [PDIP] (N-8) P-Suffix  
 Dimensions shown in inches and (millimeters)



COMPLIANT TO JEDEC STANDARDS MO-153AA

Figure 33. 8-Lead Thin Shrink Small Outline Package [TSSOP] (RU-8)  
 Dimensions shown in millimeters



COMPLIANT TO JEDEC STANDARDS MS-012AA  
 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 34. 8-Lead Standard Small Outline Package [SOIC\_N] Narrow Body (R-8) S-Suffix  
 Dimensions shown in millimeters and (inches)

## ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option	Ordering Quantity
REF191ES	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF191ES-REEL	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF191ESZ <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF191ESZ-REEL <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF191GS	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF191GS-REEL	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF191GSZ <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF191GSZ-REEL <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF192ES	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF192ES-REEL	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF192ES-REEL7	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	1,000
REF192ESZ <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF192ESZ-REEL <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF192ESZ-REEL7 <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	1,000
REF192FS	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF192FS-REEL	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF192FS-REEL7	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	1,000
REF192FSZ <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF192FSZ-REEL <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF192FSZ-REEL7 <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	1,000
REF192GP	-40°C to +85°C	8-Lead PDIP	P-Suffix (N-8)	
REF192GPZ <sup>1</sup>	-40°C to +85°C	8-Lead PDIP	P-Suffix (N-8)	
REF192GRU	-40°C to +85°C	8-Lead TSSOP	RU-8	
REF192GRU-REEL7	-40°C to +85°C	8-Lead TSSOP	RU-8	1,000
REF192GRUZ <sup>1</sup>	-40°C to +85°C	8-Lead TSSOP	RU-8	
REF192GRUZ-REEL7 <sup>1</sup>	-40°C to +85°C	8-Lead TSSOP	RU-8	1,000
REF192GS	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF192GS-REEL	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF192GS-REEL7	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	1,000
REF192GSZ <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF192GSZ-REEL <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF192GSZ-REEL7 <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	1,000
REF193GS	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF193GS-REEL	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF193GSZ <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF193GSZ-REEL <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF194ES	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF194ES-REEL	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF194ESZ <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF194ESZ-REEL <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF194GS	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF194GS-REEL	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF194GS-REEL7	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	1,000
REF194GSZ <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF194GSZ-REEL <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF194GSZ-REEL7 <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	1,000
REF195ES	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF195ES-REEL	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF195ESZ <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF195ESZ-REEL <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF195FS	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	

# REF19x Series

Model	Temperature Range	Package Description	Package Option	Ordering Quantity
REF195FS-REEL	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF195FSZ <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF195FSZ-REEL <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF195GP	-40°C to +85°C	8-Lead PDIP	P-Suffix (N-8)	
REF195GPZ <sup>1</sup>	-40°C to +85°C	8-Lead PDIP	P-Suffix (N-8)	
REF195GRU	-40°C to +85°C	8-Lead TSSOP	RU-8	
REF195GRU-REEL7	-40°C to +85°C	8-Lead TSSOP	RU-8	1,000
REF195GRUZ <sup>1</sup>	-40°C to +85°C	8-Lead TSSOP	RU-8	
REF195GRUZ-REEL7 <sup>1</sup>	-40°C to +85°C	8-Lead TSSOP	RU-8	1,000
REF195GS	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF195GS-REEL	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF195GS-REEL7	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	1,000
REF195GSZ <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF195GSZ-REEL <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF195GSZ-REEL7 <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	1,000
REF196GRU-REEL7	-40°C to +85°C	8-Lead TSSOP	RU-8	1,000
REF196GRUZ-REEL7 <sup>1</sup>	-40°C to +85°C	8-Lead TSSOP	RU-8	1,000
REF196GS	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF196GS-REEL	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF196GSZ <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF196GSZ-REEL <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF196GSZ-REEL7 <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	1,000
REF198ES	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF198ES-REEL	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF198ESZ <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF198ESZ-REEL <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF198ESZ-REEL7 <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	1,000
REF198FS	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF198FS-REEL	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF198FSZ <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF198FSZ-REEL <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF198GRU	-40°C to +85°C	8-Lead TSSOP	RU-8	
REF198GRU-REEL7	-40°C to +85°C	8-Lead TSSOP	RU-8	1,000
REF198GRUZ <sup>1</sup>	-40°C to +85°C	8-Lead TSSOP	RU-8	
REF198GRUZ-REEL7 <sup>1</sup>	-40°C to +85°C	8-Lead TSSOP	RU-8	2,500
REF198GS	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF198GS-REEL	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF198GSZ <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF198GSZ-REEL <sup>1</sup>	-40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500

<sup>1</sup> Z = RoHS Compliant Part.

