Precision Micropower, Low Dropout Voltage References

REF19x Series

FEATURES

Initial accuracy: ±2 mV maximum
Temperature coefficient: 5 ppm/°C maximum
Low supply current: 45 µA maximum
Sleep mode: 15 µA 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.

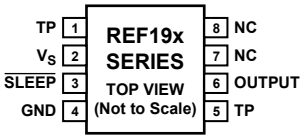
The REF19x series is made up of micropower, low dropout voltage (LDV) devices, providing stable output voltage from supplies as low as 100 mV above the output voltage and consuming less than 45 µA of supply current. In sleep mode, which is enabled by applying a low TTL or CMOS level to the $\overline{\text{SLEEP}}$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

The REF19x series references are specified over the extended industrial temperature range (−40°C to +85°C) with typical performance specifications over −40°C to +125°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

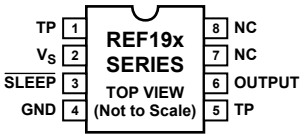
Test Pin 1 and Test Pin 5 are reserved for in-package Zener zap. To achieve the highest level of accuracy at the output, the Zener zapping technique is used to trim the output voltage. Because each unit may require a different amount of adjustment, the resistance value at the test pins varies widely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

SPECIFICATIONS

ELECTRICAL CHARACTERISTICS—REF191 @ T_A = 25°C

@ V_S = 3.3 V, T_A = 25°C, unless otherwise noted.

Table 2.

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

[1] Initial accuracy includes temperature hysteresis effect.
[2] Line and load regulation specifications include the effect of self-heating.
[3] 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°C ≤ T_A ≤ +125°C

@ V_S = 3.3 V, −40°C ≤ T_A ≤ +125°C, unless otherwise noted.

Table 4.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
TEMPERATURE COEFFICIENT[1, 2]	TCV_O/°C					
E Grade		I_{OUT} = 0 mA		2		ppm/°C
F Grade				5		ppm/°C
G Grade[3]				10		ppm/°C
LINE REGULATION[4]	$\Delta V_O/\Delta V_{IN}$					
E Grade		3.0 V ≤ V_S ≤ 15 V, I_{OUT} = 0 mA		10		ppm/V
F and G Grades				20		ppm/V
LOAD REGULATION[4]	$\Delta V_O/\Delta V_{LOAD}$					
E Grade		V_S = 5.0 V, 0 mA ≤ I_{OUT} ≤ 20 mA		10		ppm/mA
F and G Grades				20		ppm/mA
DROPOUT VOLTAGE	$V_S - V_O$	V_S = 3.3 V, I_{LOAD} = 10 mA			1.25	V
		V_S = 3.6 V, I_{LOAD} = 20 mA			1.55	V

[1] For proper operation, a 1 µF capacitor is required between the output pin and the GND pin of the device.
[2] TCV_O is defined as the ratio of output change with temperature variation to the specified temperature range expressed in ppm/°C.
$TCV_O = (V_{MAX} - V_{MIN})/V_O(T_{MAX} - T_{MIN})$
[3] Guaranteed by characterization.
[4] Line and load regulation specifications include the effect of self-heating.

ELECTRICAL CHARACTERISTICS—REF192 @ T_A = 25°C

@ V_S = 3.3 V, T_A = 25°C, unless otherwise noted.

Table 5.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
INITIAL ACCURACY[1]	V_O					
E Grade		I_{OUT} = 0 mA	2.498	2.500	2.502	V
F Grade			2.495		2.505	V
G Grade			2.490		2.510	V
LINE REGULATION[2]	$\Delta V_O/\Delta V_{IN}$					
E Grade		3.0 V ≤ V_S ≤ 15 V, I_{OUT} = 0 mA		2	4	ppm/V
F and G Grades				4	8	ppm/V
LOAD REGULATION[2]	$\Delta V_O/\Delta V_{LOAD}$					
E Grade		V_S = 5.0 V, 0 mA ≤ I_{OUT} ≤ 30 mA		4	10	ppm/mA
F and G Grades				6	15	ppm/mA
DROPOUT VOLTAGE	$V_S - V_O$	V_S = 3.5 V, I_{LOAD} = 10 mA			1.00	V
		V_S = 3.9 V, I_{LOAD} = 30 mA			1.40	V
LONG-TERM STABILITY[3]	DV_O	1000 hours @ 125°C		1.2		mV
NOISE VOLTAGE	e_N	0.1 Hz to 10 Hz		25		µV p-p

[1] Initial accuracy includes temperature hysteresis effect.
[2] Line and load regulation specifications include the effect of self-heating.
[3] 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—REF192 @ −40°C ≤ T_A ≤ +85°C

@ V_S = 3.3 V, −40°C ≤ T_A ≤ +85°C, unless otherwise noted.

Table 6.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
TEMPERATURE COEFFICIENT[1, 2]	TCV_O/°C					
E Grade		I_{OUT} = 0 mA		2	5	ppm/°C
F Grade				5	10	ppm/°C
G Grade[3]				10	25	ppm/°C
LINE REGULATION[4]	$\Delta V_O/\Delta V_{IN}$					
E Grade		3.0 V ≤ V_S ≤ 15 V, I_{OUT} = 0 mA		5	10	ppm/V
F and G Grades				10	20	ppm/V
LOAD REGULATION[4]	$\Delta V_O/\Delta V_{LOAD}$					
E Grade		V_S = 5.0 V, 0 mA ≤ I_{OUT} ≤ 25 mA		5	15	ppm/mA
F and G Grades				10	20	ppm/mA
DROPOUT VOLTAGE	$V_S - V_O$	V_S = 3.5 V, I_{LOAD} = 10 mA			1.00	V
		V_S = 4.0 V, I_{LOAD} = 25 mA			1.50	V
$\overline{\text{SLEEP}}$ PIN						
Logic High Input Voltage	V_H		2.4			V
Logic High Input Current	I_H				−8	µA
Logic Low Input Voltage	V_L				0.8	V
Logic Low Input Current	I_L				−8	µA
SUPPLY CURRENT		No load			45	µA
Sleep Mode		No load			15	µA

[1] For proper operation, a 1 µF capacitor is required between the output pin and the GND pin of the device.
[2] TCV_O is defined as the ratio of output change with temperature variation to the specified temperature range expressed in ppm/°C.
$TCV_O = (V_{MAX} - V_{MIN})/V_O(T_{MAX} - T_{MIN})$
[3] Guaranteed by characterization.
[4] Line and load regulation specifications include the effect of self-heating.

ELECTRICAL CHARACTERISTICS—REF192 @ −40°C ≤ T_A ≤ +125°C

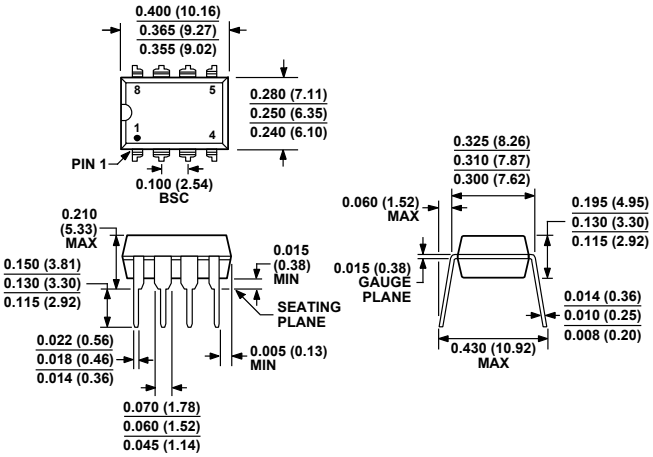
@ V_S = 3.3 V, −40°C ≤ T_A ≤ +125°C, unless otherwise noted.

Table 7.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
TEMPERATURE COEFFICIENT[1, 2]	TCV_O/°C					
E Grade		I_{OUT} = 0 mA		2		ppm/°C
F Grade				5		ppm/°C
G Grade[3]				10		ppm/°C
LINE REGULATION[4]	$\Delta V_O/\Delta V_{IN}$					
E Grade		3.0 V ≤ V_S ≤ 15 V, I_{OUT} = 0 mA		10		ppm/V
F and G Grades				20		ppm/V
LOAD REGULATION[4]	$\Delta V_O/\Delta V_{LOAD}$					
E Grade		V_S = 5.0 V, 0 mA ≤ I_{OUT} ≤ 20 mA		10		ppm/mA
F and G Grades				20		ppm/mA
DROPOUT VOLTAGE	$V_S - V_O$	V_S = 3.5 V, I_{LOAD} = 10 mA			1.00	V
		V_S = 4.0 V, I_{LOAD} = 20 mA			1.50	V

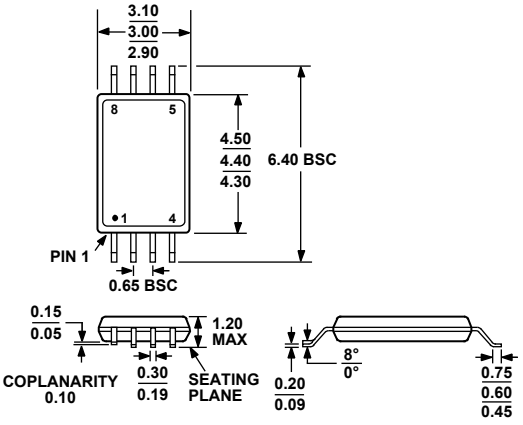
[1] For proper operation, a 1 µF capacitor is required between the output pin and the GND pin of the device.
[2] TCV_O is defined as the ratio of output change with temperature variation to the specified temperature range expressed in ppm/°C.
$TCV_O = (V_{MAX} - V_{MIN})/V_O(T_{MAX} - T_{MIN})$
[3] Guaranteed by characterization.
[4] Line and load regulation specifications include the effect of self-heating.

OUTLINE DIMENSIONS



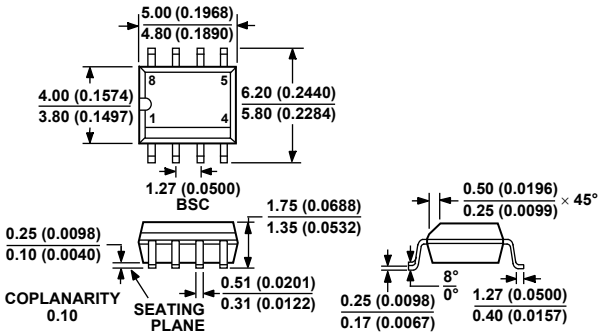
COMPLIANT TO JEDEC STANDARDS MS-001-BA
CONTROLLING DIMENSIONS ARE IN INCHES; MILLIMETER DIMENSIONS (IN PARENTHESES) ARE ROUNDED-OFF INCH EQUIVALENTS FOR REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN. CORNER LEADS MAY BE CONFIGURED AS WHOLE OR HALF LEADS.

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[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF191ESZ-REEL[1]	−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[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF191GSZ-REEL[1]	−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[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF192ESZ-REEL[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF192ESZ-REEL7[1]	−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[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF192FSZ-REEL[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF192FSZ-REEL7[1]	−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[1]	−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[1]	−40°C to +85°C	8-Lead TSSOP	RU-8	
REF192GRUZ-REEL7[1]	−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[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF192GSZ-REEL[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF192GSZ-REEL7[1]	−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[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF193GSZ-REEL[1]	−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[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF194ESZ-REEL[1]	−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[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF194GSZ-REEL[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF194GSZ-REEL7[1]	−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[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF195ESZ-REEL[1]	−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)	

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[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF195FSZ-REEL[1]	−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[1]	−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[1]	−40°C to +85°C	8-Lead TSSOP	RU-8	
REF195GRUZ-REEL7[1]	−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[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF195GSZ-REEL[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF195GSZ-REEL7[1]	−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[1]	−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[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF196GSZ-REEL[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF196GSZ-REEL7[1]	−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[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF198ESZ-REEL[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500
REF198ESZ-REEL7[1]	−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[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF198FSZ-REEL[1]	−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[1]	−40°C to +85°C	8-Lead TSSOP	RU-8	
REF198GRUZ-REEL7[1]	−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[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	
REF198GSZ-REEL[1]	−40°C to +85°C	8-Lead SOIC_N	S-Suffix (R-8)	2,500

[1] Z = RoHS Compliant Part.