+5V, +10V Precision Voltage References

REF01/REF02

_____General Description

The REF01/REF02 are industry-standard precision voltage references. The stable 10V output of the REF01 can be adjusted over a ±6% range with minimal effect on temperature stability. The 5V output REF02 can also be adjusted over a ±6% range. The 10V REF01 has a single-supply operation over an input voltage range of 13V to 33V, while the 5V REF02 has a single-supply operation over an input voltage range of 7V to 33V. Both devices offer a low-current drain of 1mA. The REF02 also provides a TEMP pin whose output voltage varies linearly with temperature, making this device suitable for a wide variety of temperature-sensing and control applications. For new designs, refer to the MAX6035 or MAX6143 data sheets.

_____Features

♦ **Pretrimmed to +5V, +10V**

♦ **Excellent Temperature Stability: 3ppm/°C (typ)**

♦ **Low Noise: 10µV$_{P-P}$ (REF02)**

♦ **Short-Circuit Protected**

♦ **Linear Temperature Transducer Output (REF02)**

_____Ordering Information

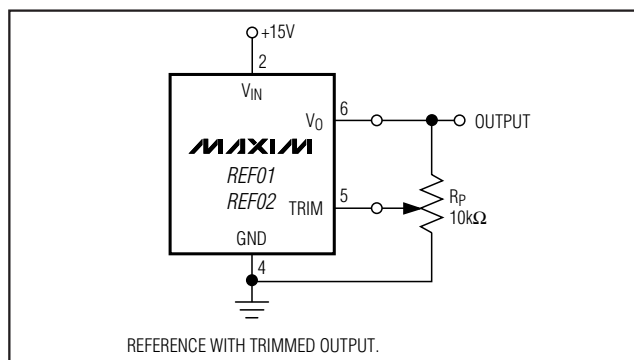| PART	TEMP RANGE	MAX TEMPCO (ppm/°C)	INITIAL ERROR (mV)	PIN-PACKAGE	PKG CODE
REF01EP	0°C to +70°C	8.5	±30	8 Plastic DIP	P8-2
REF01EP+	0°C to +70°C	8.5	±30	8 Plastic DIP	P8-2
REF01HP	0°C to +70°C	25	±50	8 Plastic DIP	P8-2
REF01HP+	0°C to +70°C	25	±50	8 Plastic DIP	P8-2
REF01HSA	0°C to +70°C	25	±50	8 SO	S8-2
REF01HSA+	0°C to +70°C	25	±50	8 SO	S8-2
REF01CP	0°C to +70°C	65	±100	8 Plastic DIP	P8-2
REF01CP+	0°C to +70°C	65	±100	8 Plastic DIP	P8-2
REF01CSA	0°C to +70°C	65	±100	8 SO	S8-2
REF01CSA+	0°C to +70°C	65	±100	8 SO	S8-2
REF01CESA	-40°C to +85°C	65	±100	8 SO	S8-2
REF01CESA+	-40°C to +85°C	65	±100	8 SO	S8-2

+*Denotes a lead-free package.*

Ordering Information continued at end of data sheet.

_____Applications

Analog-to-Digitial Converters

Digitial-to-Analog Converters

Digital Voltmeters

Voltage Regulators

Threshold Detectors

_____Typical Operating Circuit

REFERENCE WITH TRIMMED OUTPUT.

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For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

REF01/REF02

ABSOLUTE MAXIMUM RATINGS–REF01

Input Voltage
  REF01, E, H...40V
  REF01C 30V
Continuous Power Dissipation
  Plastic Dip (P) (derate at 5.6mW/°C above +36°C) 500mW
  Small Outline (S) (derate at 5.0mW/°C above +55°C) ..300mW

Output Short-Circuit Duration
  (to ground or V$_{IN}$) ....Indefinite
Storage Temperature Range ....-65°C to +150°C
Operating Temperature Range
  REF01E, REF01H, REF01C
  (except REF01CESA)...0°C to +70°C
  REF01CESA ....-40°C to +85°C
Lead Temperature (soldering, 60s) ....+300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS—REF01E/REF01H

(V$_{IN}$ = +15V, **T$_A$ = +25°C**, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	REF01E			REF01H			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Output Voltage	V$_O$	I$_L$ = 0	9.97	10.00	10.03	9.95	10.00	10.05	V
Output Adjustment Range	ΔV$_{trim}$	R$_P$ = 10kΩ	±3.0	±6.0		±3.0	±6.0		%
Output Voltage Noise	e$_{nP-P}$	0.1Hz to 10Hz (Note 1)		20	30		20	30	μV$_{P-P}$
Line Regulation		V$_{IN}$ = 13V to 33V (Note 2)		0.006	0.010		0.006	0.010	%/V
Load Regulation		I$_L$ = 0 to 10mA (Note 2)		0.005	0.008		0.006	0.010	%/mA
Turn-On Settling Time	t$_{ON}$	To ±0.1% of final value		400			400		μs
Quiescent Supply Current	I$_{SY}$	No load		1.0	1.4		1.0	1.4	mA
Load Current	I$_L$	To specified output voltage tolerance	10	21		10	21		mA
Sink Current	I$_S$	To specified output voltage tolerance	0.3	0.5		0.3	0.5		mA
Short-Circuit Current	I$_{SC}$	V$_O$ = 0V		30			30		mA

ELECTRICAL CHARACTERISTICS—REF01E/REF01H

(V$_{IN}$ = +15V, **0°C ≤ T$_A$ ≤ +70°C for REF01E and REF01H**, I$_L$ = 0mA, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	REF01E			REF01H			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Output Voltage Change with Temperature	ΔV$_{OT}$	0°C ≤ T$_A$ ≤ +70°C (Note 3)		0.02	0.06		0.07	0.17	%
Output Voltage Temperature Coefficient	TCV$_O$	(Note 4)		3	8.5		10.0	25.0	ppm/°C
Change in V$_O$ Temperature Coefficient with Output Adjustment		R$_P$ = 10kΩ		0.7			0.7		ppm/%
Line Regulation (V$_{IN}$ = 13V to 33V)		0°C ≤ T$_A$ ≤ +70°C (Note 2)		0.007	0.012		0.007	0.012	%/V
Load Regulation (I$_L$ = 0 to 8mA)		0°C ≤ T$_A$ ≤ +70°C (Note 2)		0.006	0.010		0.007	0.012	%/mA

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ELECTRICAL CHARACTERISTICS—REF01C

(V_{IN} = +15V, **T_A = +25°C**, I_L = 0mA, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	REF01C MIN	REF01C TYP	REF01C MAX	UNITS
Output Voltage	V_O	I_L = 0mA	9.90	10.00	10.10	V
Output Adjustment Range	ΔV_{trim}	R_P = 10kΩ	±2.7	±6.0		%
Output Voltage Noise	e_{nP-P}	0.1Hz to 10Hz (Note 1)		25	35	µV$_{P-P}$
Line Regulation		V_{IN} = 13V to 30V (Note 2)		0.009	0.015	%/V
Load Regulation (Note 2)		I_L = 0 to 8mA		0.006	0.015	%/mA
		I_L = 0 to 4mA		0.006	0.015	
Turn-On Settling Time	t_{ON}	To ±0.1% of final value		400		µs
Quiescent Supply Current	I_{SY}	No load		1.0	1.6	mA
Load Current	I_L	To specified output voltage tolerance	8	21		mA
Sink Current	I_S	To specified output voltage tolerance	0.2	0.5		mA
Short-Circuit Current	I_{SC}	V_O = 0V		30		mA

ELECTRICAL CHARACTERISTICS—REF01C

(V_{IN} = +15V, **T_A = T_{MIN} to T_{MAX}**, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	REF01C MIN	REF01C TYP	REF01C MAX	UNITS
Output Voltage Change with Temperature	ΔV_{OT}	(Note 3)		0.14	0.45	%
Output Voltage Temperature Coefficient	TCV_O	(Note 4)		20	65	ppm/°C
Change in V_O Temperature Coefficient with Output Adjustment		R_P = 10kΩ		0.7		ppm/%
Line Regulation		V_{IN} = 13V to 30V (Note 2)		0.011	0.018	%/V
Load Regulation		I_L = 0 to 5mA (Note 2)		0.008	0.018	%/mA

Note 1: Guaranteed by design.

Note 2: Line and load regulation specifications include the effect of self heating. 100% production tested at T_A = +25°C and guaranteed by design for T_A = T_{MIN} to T_{MAX}, as specified.

Note 3: ΔV_{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 10V. Guaranteed by design.

$$\Delta V_{OT} = \left[\frac{V_{MAX} - V_{MIN}}{10V}\right] \times 100$$

Note 4: TCV_O is defined as ΔV_{OT} divided by the temperature range. Guaranteed by design.

_____Output Adjustment

The REF01 trim terminal can be used to adjust the voltage over a 10V ±600mV range. This feature allows the system designer to trim system errors by setting the reference to a voltage other than 10V, including 10.240V for binary applications (see the _Typical Operating Circuit_).

Adjustment of the output does not significantly affect the temperature performance of the device. The temperature coefficient change is approximately 0.7ppm/°C for 100mV of output adjustment.

+5V, +10V Precision Voltage References

ABSOLUTE MAXIMUM RATINGS–REF02

Input Voltage
  REF02, E, H..40V
  REF02C 30V
Continuous Power Dissipation
  Plastic Dip (P) (derate at 5.6mW/°C above +36°C) 500mW
  Small Outline (S) (derate at 5.0mW/°C above +55°C)..300mW
Storage Temperature Range ....-65°C to +150°C

Operating Temperature Range
  REF02E, REF02H ....0°C to +70°C
  REF02C (except REF02CESA) ....0°C to +70°C
  REF02CESA...-40°C to +85°C
Output Short-Circuit Duration
  (to ground or V_{IN}) ....Indefinite
Lead Temperature (soldering, 60s) ....+300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS—REF02E/REF02H

(V_{IN} = +15V, **T_A = +25°C**, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	REF02E			REF02H			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Output Voltage	V_O	I_L = 0	4.985	5.000	5.015	4.975	5.000	5.025	V
Output Adjustment Range	ΔV_{trim}	R_P = 10kΩ	±3	±6		±3	±6		%
Output Voltage Noise	e_{nP-P}	0.1Hz to 10Hz (Note 5)		10	15		10	15	µVP-P
Line Regulation		V_{IN} = 8V to 33V (Note 6)		0.006	0.010		0.006	0.010	%/V
Load Regulation		I_L = 0 to 10mA (Note 6)		0.005	0.010		0.006	0.010	%/mA
Turn-On Settling Time	t_{ON}	To ±0.1% of final value		230			230		µs
Quiescent Supply Current	I_{SY}	No load		1.0	1.4		1.0	1.4	mA
Load Current	I_L	To specified output voltage tolerance	10	21		10	21		mA
Sink Current	I_S	To specified output voltage tolerance	0.3	0.5		0.3	0.5		mA
Short-Circuit Current	I_{SC}	V_O = 0V		30			30		mA
Temperature Voltage Output	V_T	(Note 7)		630			630		mV

ELECTRICAL CHARACTERISTICS—REF02E/REF02H

(V_{IN} = +15V, **0°C ≤ T_A ≤ +70°C for REF02E and REF02H**, I_L = 0mA, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	REF02E			REF02H			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Output Voltage Change with Temperature	ΔV_{OT}	0°C ≤ T_A ≤ +70°C (Note 8)		0.02	0.06		0.07	0.17	%
Output Voltage Temperature Coefficient	TCV_O	(Note 9)		3	8.5		10	25	ppm/°C
Change in V_O Temperature Coefficient with Output Adjustment		R_P = 10kΩ		0.7			0.7		ppm/%
Line Regulation (V_{IN} = 8V to 33V)		0°C ≤ T_A ≤ +70°C (Note 6)		0.007	0.012		0.007	0.012	%/V
Load Regulation (I_L = 0 to 8mA)		0°C ≤ T_A ≤ +70°C (Note 6)		0.006	0.010		0.007	0.012	%/mA

ELECTRICAL CHARACTERISTICS—REF02E/REF02H (continued)

(V_{IN} = +15V, **0°C ≤ T_A ≤ +70°C for REF02E and REF02H**, I_L = 0mA, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	REF02E			REF02H			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Temperature Voltage Output Temperature Coefficient	TCV_T	(Note 7)		2.1			2.1		mV/°C

ELECTRICAL CHARACTERISTICS—REF02C

(V_{IN} = +15V, **T_A = +25°C**, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	REF02C			UNITS
			MIN	TYP	MAX	
Output Voltage	V_O	I_L = 0mA	4.950	5.000	5.050	V
Output Adjustment Range	ΔV_{trim}	R_P = 10kΩ	±2.7	±6.0		%
Output Voltage Noise	e_{nP-P}	0.1Hz to 10Hz (Note 5)		12	18	µVP-P
Line Regulation		V_{IN} = 8V to 30V (Note 6)		0.009	0.015	%/V
Load Regulation (Note 6)		I_L = 0 to 8mA		0.006	0.015	%/mA
		I_L = 0 to 4mA				
Turn-On Settling Time	t_{ON}	To ±0.1% of final value		230		µs
Quiescent Supply Current	I_{SY}	No load		1.0	1.6	mA
Load Current	I_L	To specified output voltage tolerance	8	21		mA
Sink Current	I_S	To specified output voltage tolerance	0.2	0.5		mA
Short-Circuit Current	I_{SC}	V_O = 0V		30		mA
Temperature Voltage Output	V_T	(Note 7)		630		mV

ELECTRICAL CHARACTERISTICS—REF02C

(V_{IN} = +15V, **T_A = T_{MIN} to T_{MAX}**, I_L = 0mA, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	REF02C			UNITS
			MIN	TYP	MAX	
Output Voltage Change with Temperature	ΔV_{OT}	(Note 8)		0.14	0.45	%
Output Voltage Temperature Coefficient	TCV_O	(Note 9)		20	65	ppm/°C
Change in V_O Temperature Coefficient with Output Adjustment		R_P = 10kΩ		0.7		ppm/%
Line Regulation		V_{IN} = 8V to 30V (Note 6)		0.011	0.018	%/V
Load Regulation		I_L = 0 to 5mA (Note 6)		0.008	0.018	%/mA
Temperature Voltage Output Temperature Coefficient	TCV_T	(Note 7)		2.1		mV/°C

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+5V, +10V Precision Voltage References

ELECTRICAL CHARACTERISTICS–REF02 (continued)

(V_{IN} = +15V, **T_A = T_{MIN} to T_{MAX}**, I_L = 0mA, unless otherwise noted.)

Note 5: Guaranteed by design.

Note 6: Line and load regulation specifications include the effect of self heating. 100% production tested at T_A = +25°C and guaranteed by design for T_A = T_{MIN} to T_{MAX}, as specified.

Note 7: Limit current in or out of pin 3 to 50nA and capacitance on pin 3 to 30pF.

Note 8: ΔV_{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 5V. Guaranteed by design.

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

Note 9: TCV_O is defined as ΔV_{OT} divided by the temperature range. Guaranteed by design.

_____Output Adjustment

The REF02 trim terminal can be used to adjust the output voltage over a 5V ±300mV range. This feature allows the system designer to trim system errors by setting the reference to a voltage other than 5V (refer to the *Typical Operating Circuit*).

Adjustment of the output does not significantly affect the temperature performance of the device. Typically, the temperature coefficient change is 0.7ppm/°C for 100mV of output adjustment.

_____Temperature Voltage Output

The REF02 provides a temperature-dependent output voltage on the TEMP pin. This voltage is proportional to the absolute temperature, and has a scale factor of approximately 2.1mV/°C (Figure 1).

Output Voltage = 2.1(T + 273)mV

where T = Temperature in °C.
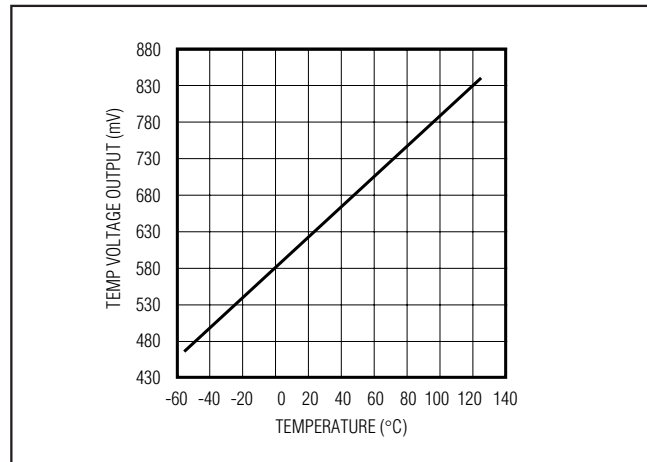
Figure 1. REF02 Temperature/Voltage Output vs. Temperature

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REF01/REF02

Typical Operating Characteristics

(T$_A$ = +25°C, unless otherwise noted.)

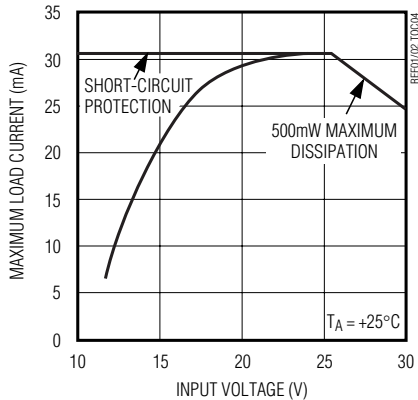**LINE REGULATION vs. FREQUENCY**
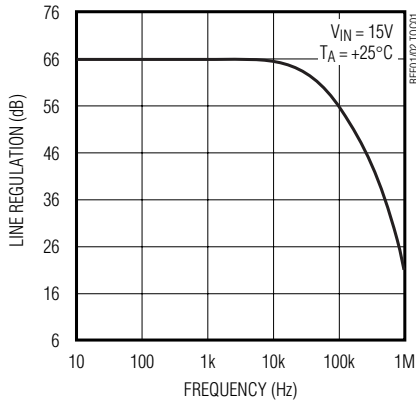
REF01 OUTPUT WIDEBAND NOISE vs. BANDWIDTH (0.1Hz TO FREQUENCY INDICATED)
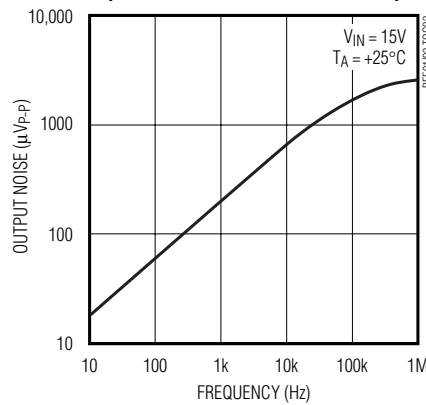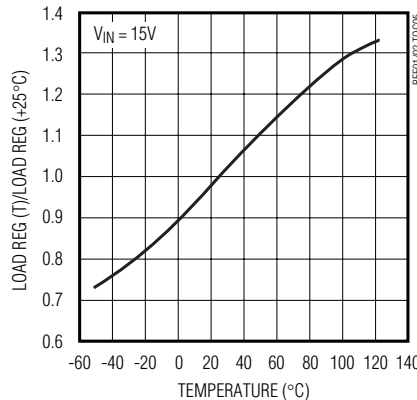

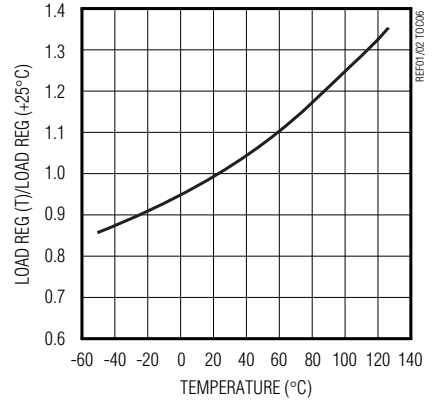**REF02 OUTPUT WIDEBAND NOISE vs. BANDWIDTH (0.1Hz TO FREQUENCY INDICATED)**
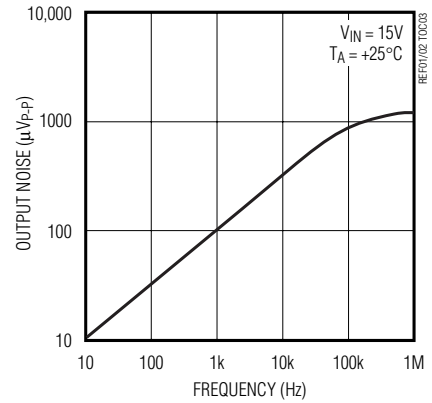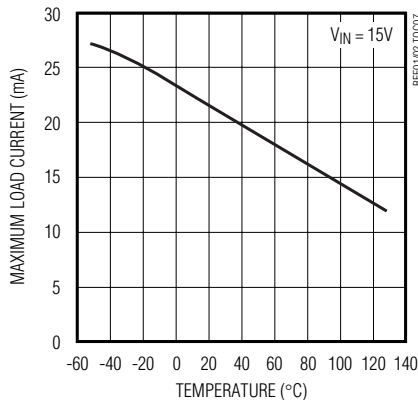

MAXIMUM LOAD CURRENT vs. INPUT VOLTAGE

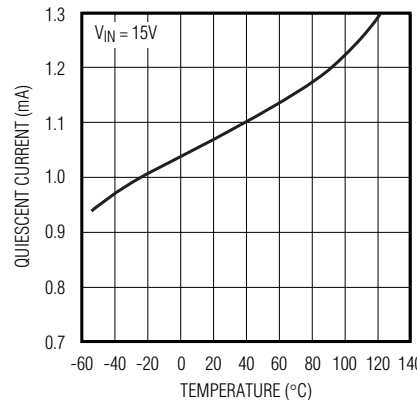**NORMALIZED LOAD REGULATION (ΔI$_L$ = 10mA) vs. TEMPERATURE**
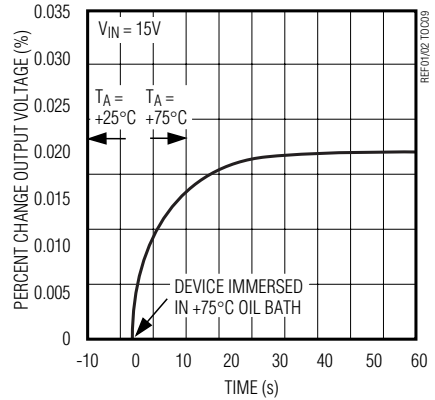

NORMALIZED LINE REGULATION vs. TEMPERATURE

MAXIMUM LOAD CURRENT vs. TEMPERATURE

QUIESCENT CURRENT vs. TEMPERATURE

OUTPUT CHANGE DUE TO THERMAL SHOCK

+5V, +10V Precision
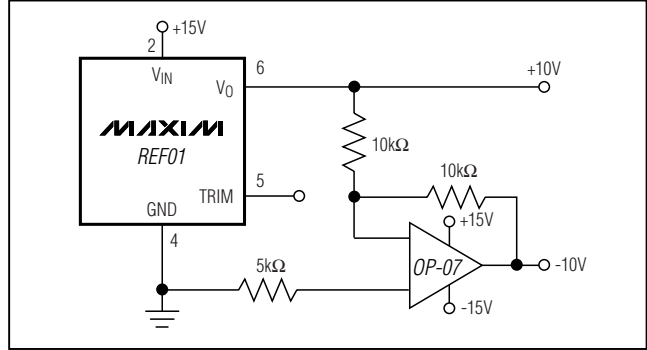# Voltage References
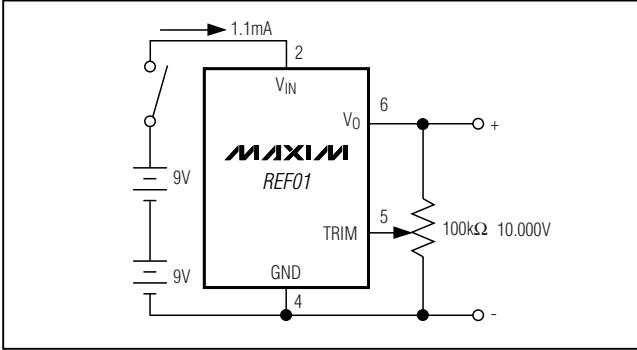
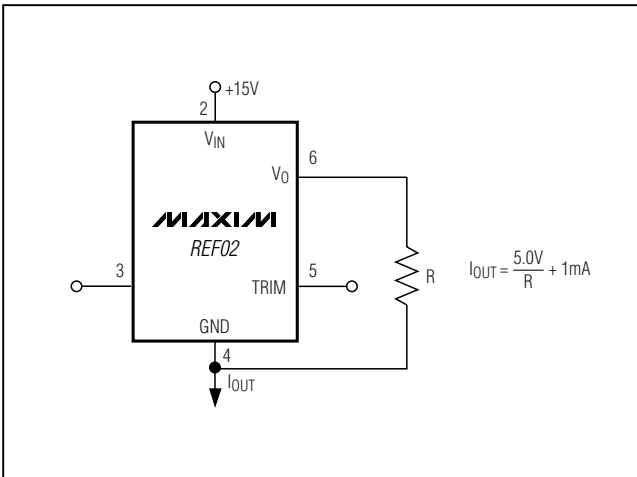Figure 2. Precision Calibration Standard

Figure 3. ±10V Reference

$$I_{OUT} = \frac{5.0V}{R} + 1mA$$

Figure 4. Current Source

*UP TO 10 FEET OF SHIELDED
4-CONDUCTOR CABLE.
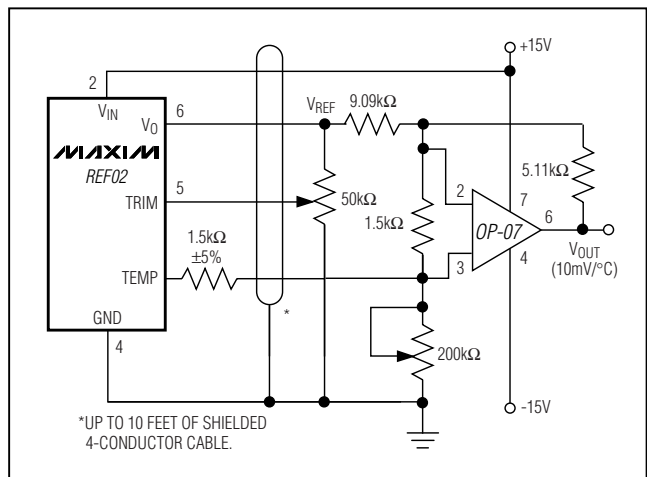
Figure 5. Precision Temperature Transducer with
Remote Sensor

MAXIM

Pin Configurations

TOP VIEW

```
        N.C. | 1        8 | N.C.
         VIN | 2        7 | N.C.
  N.C./TEMP* | 3        6 | VOUT
         GND | 4        5 | TRIM
              MAXIM
              REF01/
              REF02
                DIP
```

```
        N.C. | 1        8 | N.C.
         VIN | 2        7 | N.C.
  N.C./TEMP* | 3        6 | VOUT
         GDN | 4        5 | TRIM
              MAXIM
              REF01/
              REF02
                 SO
```

*__NOTE:__ PIN 3 IS N.C. (NO CONNECTION) ON REF01, TEMP OUTPUT ON REF02.
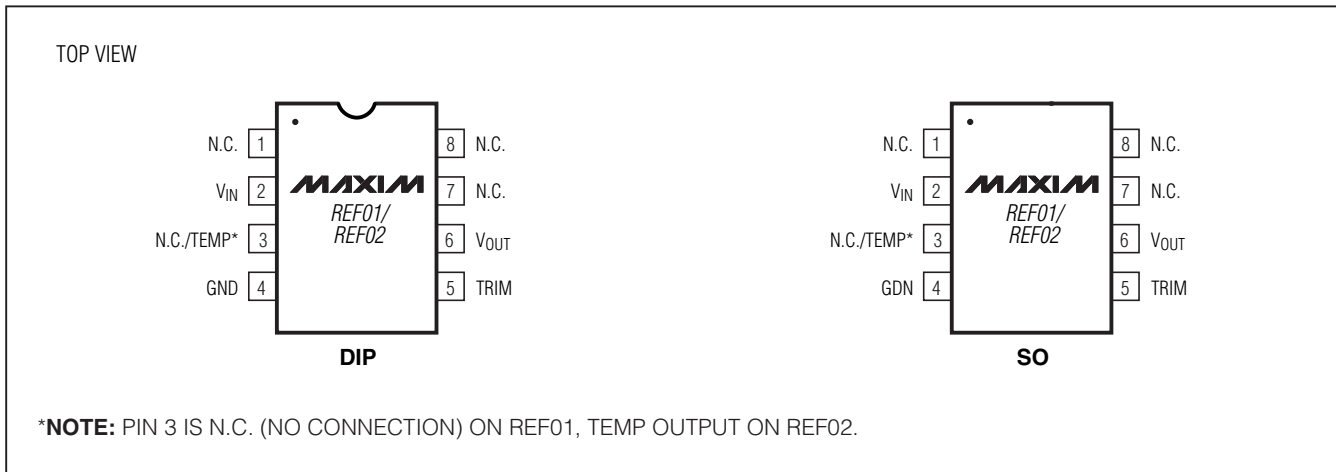
Ordering Information (continued)

PART	TEMP RANGE	MAX TEMPCO (ppm/°C)	INITIAL ERROR (mV)	PIN-PACKAGE	PKG CODE
REF02EP	0°C to +70°C	8.5	±15	8 Plastic DIP	P8-2
REF02EP+	0°C to +70°C	8.5	±15	8 Plastic DIP	P8-2
REF02HP	0°C to +70°C	25	±25	8 Plastic DIP	P8-2
REF02HP+	0°C to +70°C	25	±25	8 Plastic DIP	P8-2
REF02HSA	0°C to +70°C	25	±25	8 SO	S8-2
REF02HSA+	0°C to +70°C	25	±25	8 SO	S8-2
REF02CP	0°C to +70°C	65	±50	8 Plastic DIP	P8-2
REF02CP+	0°C to +70°C	65	±50	8 Plastic DIP	P8-2
REF02CSA	0°C to +70°C	65	±50	8 SO	S8-2
REF02CSA+	0°C to +70°C	65	±50	8 SO	S8-2
REF02CESA	-40°C to +85°C	65	±50	8 SO	S8-2
REF02CESA+	-40°C to +85°C	65	±50	8 SO	S8-2

+Denotes a lead-free package.

Revision History

Pages changed at Rev 7: 1, 9

Package Information

For the latest package outline information, go to **www.maxim-ic.com/packages**.

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