

General Description

The REF01 and REF02 are precision voltage references that are pretrimmed to within ±3% of +10V and +5V, respectively. Both references feature excellent temperature stability (as low as 8.5 ppm/°C worst case), low current drain, and low noise. 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. Both devices are available from Maxim in the space-saving SO package, as well as in the standard 8-pin TO-99 and MINI-DIP packages.

Features

♦ Pretrimmed to +5V, +10V ±0.3%

♦ Excellent Temperature Stability: 3ppm/°C

♦ Low Noise: 10µVp-p (REF02)

♦ Low Supply Current: 1.4mA max

♦ Short-Circuit Proof

♦ Linear Temperature Transducer O/P (REF02)

Ordering Information

PART	TEMP. RANGE	MAX TEMPCO (ppm/°C)	INITIAL ERROR (mV)	PIN-PACKAGE
REF01EP	0°C to +70°C	8.5	±30	8 Plastic DIP
REF01EZ	0°C to +70°C	8.5	±30	8 CERDIP
REF01HP	0°C to +70°C	25	±50	8 Plastic DIP
REF01HSA	0°C to +70°C	25	±50	8 SO
REF01CP	0°C to +70°C	65	±100	8 Plastic DIP
REF01CSA	0°C to +70°C	65	±100	8 SO
REF01CZ	0°C to +70°C	65	±100	8 CERDIP
REF01CESA	-40°C to +85°C	65	±100	8 SO
REF01Z	-55°C to +125°C	25	±50	8 CERDIP
REF02EP	0°C to +70°C	8.5	±15	8 Plastic DIP
REF02EZ	0°C to +70°C	8.5	±15	8 CERDIP
REF02HP	0°C to +70°C	25	±25	8 Plastic DIP
REF02HSA	0°C to +70°C	25	±25	8 SO
REF02CP	0°C to +70°C	65	±50	8 Plastic DIP
REF02CSA	0°C to +70°C	65	±50	8 SO
REF02CZ	0°C to +70°C	65	±50	8 CERDIP
REF02CESA	-40°C to +85°C	65	±50	8 SO
REF02Z	-55°C to +125°C	25	±25	8 CERDIP

Ordering Information continued at end of data sheet.

Applications

A to D Converters

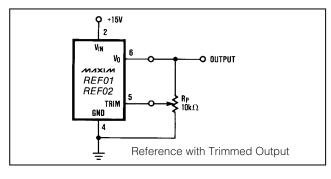
D to A Converters

Digital Voltmeters

Voltage Regulators

Threshold Detectors

Typical Operating Circuit



MIXIM

Maxim Integrated Products 1

ABSOLUTE MAXIMUM RATINGS—REF01

Input Voltage
REF01, A, E, H, All DICE40V
REF01C30V
Power Dissipation
T099 (J) (derate at 7.1mW°C above 80°C)500mW
CERDIP (2) (derate at 6.7mW/°C above 75°C)500mW
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	
REF01A, REF01	55°C to +125°C
REF01E, REF01H, REF01C	
(except REF01CESA)	0°C to +70°C
REF01CESA	40°C to +85°C
DICE Junction Temperature (T	j)65°C to +150°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—REF01

 $(V_{IN} = +15V, T_A = +25^{\circ}C, unless otherwise noted.)$

DADAMETER	0744001	CONDITIONS	F	REF01A/	Ε		UNITS		
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	UNIIS
Output Voltage	Vo	I _L = 0	9.97	10.00	10.03	9.95	10.00	10.05	V
Output Adjustment Range	ΔV_{trim}	$R_p = 10k\Omega$	±3.0	±3.3	_	±3.0	±3.3		%
Output Voltage Noise	e _{np-p}	0.1Hz to 10Hz (Note 5)		20	30	_	20	30	μV _{p-p}
Line Regulation (Note 4)		V _{IN} = 13V to 33V	_	0.006	0.010	_	0.006	0.010	%/V
Load Regulation (Note 4)		I _L = 0 to 10mA	_	0.005	0.008	_	0.006	0.010	%/mA
Turn-on Settling Time	t _{ON}	To ±0.1% of final value	_	5		_	5		μS
Quiescent Supply Current	I _{SY}	No Load	_	1.0	1.4	_	1.0	1.4	mA
Load Current	IL		10	21	<u> </u>	10	21	_	mA
Sink Current	Is		-0.3	-0.5	_	-0.3	-0.5	-	mA
Short-Circuit Current	I _{sc}	V _O = 0	_	30		_	30	_	mA

ELECTRICAL CHARACTERISTICS—REF01

 $(V_{IN} = +15V, -55^{\circ}C \le T_{A} = +125^{\circ}C$ for REF01A and REF01, $0^{\circ}C \le T_{A} \le +70^{\circ}C$ for REF01E and REF01H, $I_{L} = 0$ mA, unless otherwise noted.)

D. D. LAFTED			F	REF01A/E			REF01/H			
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	UNITS	
Output Voltage Change with Temperature (Notes 1, 2)	ΔV_{OT}	0°C ≤ T _A ≤ +70°C -55°C ≤ T _A ≤ +125°C	=	0.02 0.06	0.06 0.15	_	0.07 0.18	0.17 0.45	%	
Output Voltage Temperature Coefficient	TCVO	(Note 3)	_	3.0	8.5	_	10.0	25.0	ppm/°C	
Change in V _O Temperature Coefficient with Output Adjustment		$R_p = 10k\Omega$	_	0.7	_	_	0.7	_	ppm/%	
Line Regulation (V _{IN} = 13V to 33V)(Note 4)		$0^{\circ}C \le T_{A} \le +70^{\circ}C$ -55°C \le T_{A} \le +125°C	_	0.007 0.009	0.012 0.015	_	0.007	0.012 0.015	%/V	
Load Regulation (I _L = 0 to 8mA)(Note 4)		$0^{\circ}C \le T_{A} \le +70^{\circ}C$ -55°C \le T_{A} \le +125°C	_	0.006 0.007	0.010 0.012	_	0.007 0.009	0.012 0.015	%/mA	

Note 1: 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:

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

Note 2: ΔV_{OT} specification applies trimmed to +10.000V or untrimmed.

Note 3: TCV_O is defined as ΔV_{OT} divided by the temperature range.

Note 4: Line and Load Regulation specifications include the effect of self heating.

Note 5: Sample tested.

ELECTRICAL CHARACTERISTICS—REF01 (continued)

 $(V_{IN} = +15V, T_A = +25^{\circ}C, unless otherwise noted.)$

PARAMETER	SYMBOL	CONDITIONS		REF01C		
FANAIVIE I EN	STMBUL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	Vo	I _L = 0mA	9.90	10.00	10.10	V
Output Adjustment Range	ΔV_{trim}	$R_p = 10k\Omega$	±2.7	±3.3		%
Output Voltage Noise	e _{np-p}	0.1Hz to 10Hz (Note 5)	_	25	35	μV _{p-p}
Line Regulation (Note 4)		V _{IN} = 13V to 30V	_	0.009	0.015	%/V
Load Regulation (Note 4)		I _L = 0 to 8mA I _L = 0 to 4mA		0.006 0.006	0.015 0.015	%/mA
Turn-on Settling Time	t _{ON}	To ±0.1% of final value	_	5	_	μS
Quiescent Supply Current	I _{SY}	No Load	_	1.0	1.6	mA
Load Current	IL		8	21		mA
Sink Current	Is		-0.2	-0.5	_	mA
Short-Circuit Current	I _{sc}	V _O = 0	.—	30		mA

ELECTRICAL CHARACTERISTICS—REF01

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

PARAMETER	SYMBOL	CONDITIONS				
	STMBUL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage Change with Temperature	ΔV _{OT}	(Notes 1 and 2)	_	0.14	0.45	%
Output Voltage Temperature Coefficient	TCVo	(Note 3)	_	20	65	ppm/°C
Change in V _O Temperature Coefficient with Output Adjustment		$R_p = 10k\Omega$		0.7	_	ppm/%
Line Regulation (Note 4)		V _{IN} = 13V to 30V	_	0.011	0.018	%/V
Load Regulation (Note 4)		I _L = 0 to 5mA	_	0.008	0.018	%/mA

Notes: See previous page.

Output Adjustment

The REF01 trim terminal can be used to adjust the voltage over a 10V±300mV 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* section).

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.

ABSOLUTE MAXIMUM RATINGS—REF02

Input Voltage REF02, A, E, H, All DICE	40V
REF02C, D	
Power Dissipation	
T099 (J) (Derate at 7.1mW°C above 80°C)	500mW
CERDIP (2) (Derate at 6.7mW°C above 75°C)	
Plastic Dip (P) (Derate at 5.6mW°C above 36°C)	
Small Outline (S) (Derate at 5.0mW°C above 55°C).	300mW
Storage Temperature Range65°C to	+150°C

Operating Temperature Range	
REF02A, REF02	55°C to +125°C
REF02E, REF02H (Except REF02CESA)	0°C to +70°C
REF02C (except REF02CESA), REF02D.	0°C to +70°C
REF02CESA	40°C to +85°C
Lead Temperature (Soldering, 60s)	
DICE Junction Temperature (T _j)	65°C to +150°C
Output Short-Circuit Duration	
(to Ground or V _{IN})	Indefinite

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—REF02

 $(V_{IN} = +15V, T_A = +25^{\circ}C, unless otherwise noted.)$

PARAMETER	0744001	COMPLETONO	F	REF02A/E			REF02/H			
PAKAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	UNITS	
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}	$R_p = 10k\Omega$	±3	±6		±3	±6	_	%	
Output Voltage Noise	e _{np-p}	0.1Hz to 10Hz (Note 6)		10	15	_	10	15	μV_{p-p}	
Line Regulation (Note 1)		V _{IN} = 8V to 33V		0.006	0.010	_	0.006	0.010	%/V	
Load Regulation (Note 1)		I _L = 0 to 10mA		0.005	0.010		0.006	0.010	%/mA	
Turn-on Settling Time	t _{ON}	To ±0.1% of final value		5	T -		5		μS	
Quiescent Supply Current	I _{SY}	No Load	_	1.0	1.4	_	1.0	1.4	mA	
Load Current	ΙL		10	21		10	21		mA	
Sink Current	Is		-0.3	-0.5	_	-0.3	-0.5	_	mA	
Short-Circuit Current	I _{sc}	V _O = 0	_	30	_	_	30	-	mA	
Temperature Voltage Output	V _T	(Note 2)		630	_	_	630		mV	

ELECTRICAL CHARACTERISTICS—REF01

 $(V_{IN} = +15V, -55^{\circ}C \le T_{A} = +125^{\circ}C$ for REF02A and REF02, $0^{\circ}C \le T_{A} \le +70^{\circ}C$ for REF02E and REF02H, $I_{L} = 0$ mA, unless otherwise noted.)

DADAMETED			F	REF02A/E			REF02/H			
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	UNITS	
Output Voltage Change with Temperature (Notes 3, 4)	ΔV _{OT}	$0^{\circ}C \le T_{A} \le +70^{\circ}C$ -55°C \le T_{A} \le +125°C	_	0.02 0.06	0.06 0.15	_	0.07 0.18	0.17 0.45	%	
Output Voltage Temperature Coefficient	TCVo	(Note 5)	_	3	8.5	_	10	25	ppm/°C	
Change in V _O Temperature Coefficient with Output Adjustment		$R_p = 10k\Omega$	_	0.7	_	_	0.7	_	ppm/%	
Line Regulation (V _{IN} = 8V to 33V)(Note 1)		$0^{\circ}C \le T_{A} \le +70^{\circ}C$ -55°C \le T_{A} \le +125°C	_	0.007 0.009	0.012 0.015	_	0.007 0.009	0.012 0.015	%/V	
Load Regulation (I _L = 0 to 8mA)(Note 1)		$0^{\circ}C \le T_{A} \le +70^{\circ}C$ -55°C \le T_{A} \le +125°C	=	0.006 0.007	0.010 0.012	_	0.007 0.009	0.012 0.015	%/mA	
Temperature Voltage Output Temperature Coefficient	TCV _T	(Note 2)	_	2.1		_	2.1	_	mV/°C	

Note 1: Line and Load Regulation specifications include the effect of self heating.

Note 2: Limit current in or out of pin 3 to 50nA and capacitance on pin 3 to 30pF.

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 5V:

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

Note 4: ΔV_{OT} specification applies trimmed to +5.000V or untrimmed.

Note 5: TCV_O is defined as ΔV_{OT} divided by the temperature range.

Note 6: Sample tested.

ELECTRICAL CHARACTERISTICS—REF02

 $(V_{IN} = +15V, T_A = +25^{\circ}C, unless otherwise noted.)$

040445770	OVERDOL	CONDITIONS		REF02C		REF02D			UNITS
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	UNITS
Output Voltage	V _o	I _L = 0mA	4.950	5.000	5.050	4.900	5.000	5.100	V
Output Adjustment Range	ΔV_{trim}	$R_p = 10k\Omega$	±2.7	±6.0	_	±2.0	±6.0	_	%
Output Voltage Noise	e _{np-p}	0.1Hz to 10Hz (Note 6)		12	18	_	12	_	μV_{p-p}
Line Regulation (Note 1)		V _{IN} = 8V to 30V		0.009	0.015	_	0.010	0.04	%/V
Load Regulation (Note 1)		I _L = 0 to 8mA I _L = 0 to 4mA	_	0.006	0.015 —	_	 0.015	 0.04	%/mA
Turn-on Settling Time	t _{ON}	To ±0.1% of final value		5	_	_	5	_	μs
Quiescent Supply Current	I _{SY}	No Load	<u> </u>	1.0	1.6	_	1.0	2.0	mA
Load Current	ار		8	21	_	8	21	_	mA
Sink Current	Is		-0.2	-0.5	_	-0.2	-0.5	_	mA
Short-Circuit Current	I _{sc}	V _O = 0		30	_	_	30	-	mA
Temperature Voltage Output	V _T	(Note 2)	_	630	_	_	630	_	mV

ELECTRICAL CHARACTERISTICS—REF02

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

PARAMETER	SYMBOL	CONDITIONS	REF02C			REF02D			T
			MIN	TYP	MAX	MIN	TYP	MAX	UNITS
Output Voltage Change with Temperature	ΔV _{OT}	(Notes 3 and 4)	_	0.14	0.45	_	0.49	1.7	%
Output Voltage Temperature Coefficient	тсуо	(Note 5)	_	20	65	_	70	250	ppm/°C
Change in V _O Temperature Coefficient with Output Adjustment		R _p = 10kΩ		0.7	_	_	0.7		ppm/%
Line Regulation (Note 1)		V _{IN} = 8V to 30V	-	0.011	0.018		0.012	0.05	%/V
Load Regulation (Note 1)		I _L = 0 to 5mA	_	0.008	0.018	_	0.016	0.05	%/mA
Temperature Voltage Output Temperature Coefficient	TCV _T	(Note 2)	_	2.1	_		2.1	_	mV/°C

Notes: See previous page.

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* section).

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 2).

Output Voltage = 2.1(T + 273)mV where T = Temperature in °C

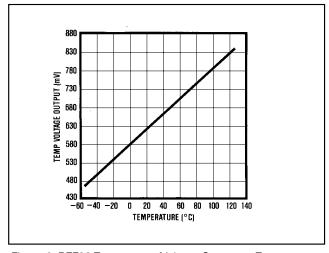
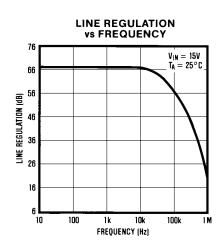
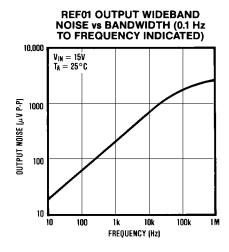
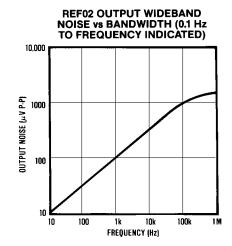


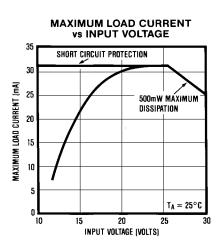
Figure 2. REF02 Temperature/Voltage Output vs. Temperature

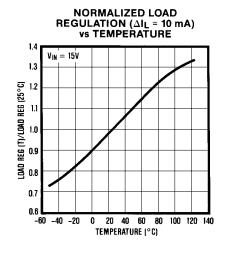
Typical Operating Characteristics

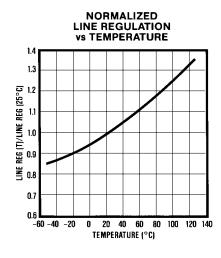


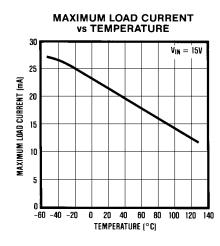


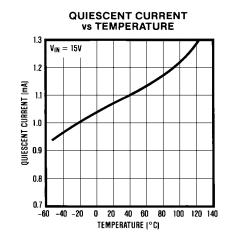


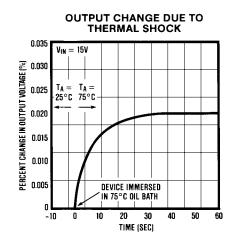












Typical Applications

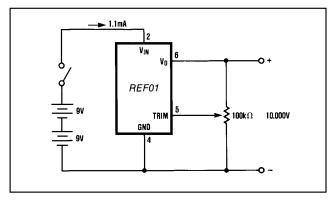


Figure 3. Precision Calibration Standard

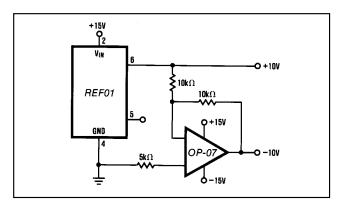


Figure 4. ±10V Reference

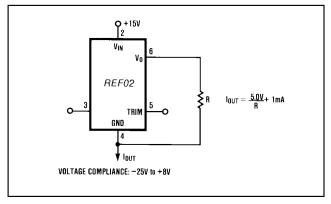


Figure 5. Current Source

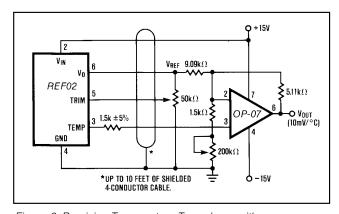
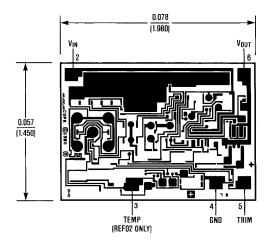


Figure 6. Precision Temperature Transducer with Remote Sensor

Chip Topography

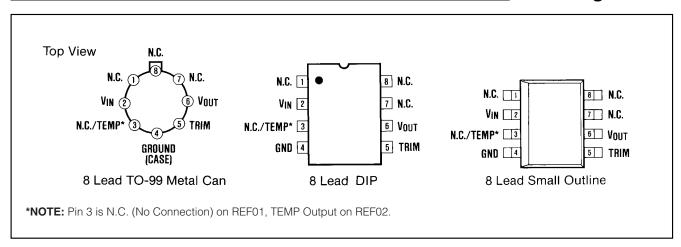


Ordering Information (continued)

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PART	TEMP. RANGE	MAX. TEMPCO (ppm/°C)	INITIAL ERROR (mV)	PIN-PACKAGE
REF01EJ*	0°C to +70°C	8.5	±30	8 TO-99
REF01HF*	0°C to +70°C	25	±50	8 TO-99
REF01CJ*	0°C to +70°C	65	±100	8 TO-99
REF01HZ*	0°C to +70°C	25	±50	8 Hermetic DIP
REF01CP-2*	0°C to +70°C	65	±100	8 Plastic DIP
REF01AJ*	-55°C to +125°C	8.5	±30	8 TO-99
REF01J*	-55°C to +125°C	25	±50	8 TO-99
REF01AZ*	-55°C to +125°C	8.5	±15	8 Hermetic DIP
REF02EJ*	0°C to +70°C	8.5	±15	8 TO-99
REF02HJ*	0°C to +70°C	25	±25	8 TO-99
REF02CJ*	0°C to +70°C	65	±50	8 TO-99
REF02DJ*	0°C to +70°C	250	±100	8 TO-99
REF02HZ*	0°C to +70°C	25	±25	8 Hermetic DIP
REF02DP*	0°C to +70°C	250	±100	8 Plastic DIP
REF02DSA*	0°C to +70°C	250	±100	8 SO
REF02AJ*	-55°C to +125°C	8.5	±15	8 TO-99
REF02J*	-55°C to +125°C	25	±25	8 TO-99
REF02AZ*	-55°C to +125°C	8.5	±15	8 Hermetic DIP

^{*}Contact factory for availability.

Pin Configuration



Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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