

## FEATURES

- Trimmed Output  $\pm 0.3\%$
- Low Drift— $5\text{ppm}/^\circ\text{C}$  Typ
- Low Noise— $3\text{ppm}_{(P-P)}$
- High Line Rejection
- Temperature Output—REF-02
- Low Supply Current 1.4mA Max

## APPLICATIONS

- A/D and D/A Converters
- Precision Regulators
- Constant Current Sources
- V/F Converters
- Bridge Excitation

## DESCRIPTION

The REF-01/REF-02 are precision 10V and 5V bandgap references which provide stable output voltages over a wide range of operating conditions. Output voltage is accurate to  $\pm 0.3\%$  with a low  $5\text{ppm}/^\circ\text{C}$  typical temperature coefficient. The REF-01 and REF-02 are excellent choices for applications where low drift, moderate accuracy, low power consumption and low cost are considerations.

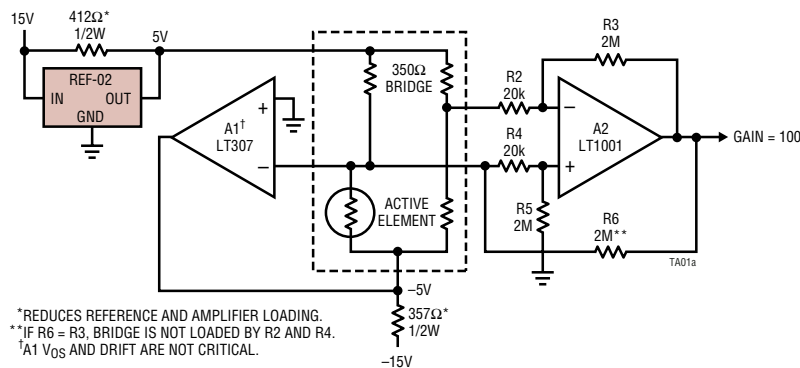
The REF-02 includes a temperature output pin which provides a linear voltage proportional to absolute temperature.

For lower drift and higher accuracy references, please see the LT1019 and LT1021 data sheets.

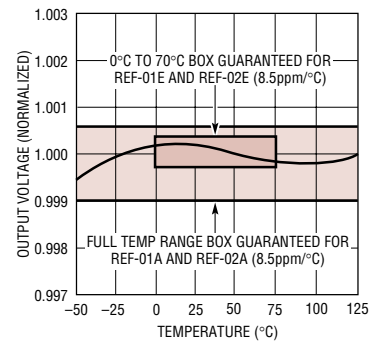
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## TYPICAL APPLICATION

Ultra Linear Strain Gauge Amplifier



Output Voltage Temperature Drift



# REF-01/REF-02

## ABSOLUTE MAXIMUM RATINGS (Note 1)

REF-01/REF-02 A, E, H .....	40V	Storage Temperature Range .....	-65°C to 150°C
REF-01C/REF-02C .....	30V	Operating Temperature	
Power Dissipation .....	500mW	REF-01/REF-02, REF-01A/REF-02A ...	-55°C to 125°C
Output Short-Circuit Duration		REF-01E/REF-02E, REF-01H/REF-02H,	
To Ground .....	Indefinite	REF-01C/REF-02C, REF-01D/REF-02D ....	0°C to 70°C
To $V_{IN} \leq 16V$ .....	Indefinite	Lead Temperature (Soldering, 10 sec) .....	300°C
To $V_{IN} > 16V$ .....	Not Allowed		

## PACKAGE/ORDER INFORMATION

<p>TOP VIEW</p> <p>NC* 8</p> <p>NC* 1</p> <p>INPUT 2</p> <p>TEMP** 3</p> <p>GND 4</p> <p>TRIM 5</p> <p>OUTPUT 6</p> <p>NC* 7</p> <p>NC* 8</p> <p>GND (CASE)</p> <p>H PACKAGE</p> <p>8-LEAD TO-5 METAL CAN</p> <p><math>T_{JMAX} = 150^{\circ}C</math>, <math>\theta_{JA} = 150^{\circ}C/W</math>, <math>\theta_{JC} = 45^{\circ}C/W</math></p> <p>* INTERNALLY CONNECTED. DO NOT CONNECT EXTERNALLY.</p> <p>** DO NOT CONNECT ON REF-01</p>	ORDER PART NUMBER		<p>TOP VIEW</p> <p>NC* 1</p> <p>INPUT 2</p> <p>TEMP** 3</p> <p>GND 4</p> <p>TRIM 5</p> <p>OUTPUT 6</p> <p>NC* 7</p> <p>NC* 8</p> <p>N8 PACKAGE</p> <p>8-LEAD PDIP</p> <p><math>T_{JMAX} = 100^{\circ}C</math>, <math>\theta_{JA} = 130^{\circ}C/W</math></p> <p>* INTERNALLY CONNECTED. DO NOT CONNECT EXTERNALLY.</p> <p>** DO NOT CONNECT ON REF-01</p>	ORDER PART NUMBER	
	<p>REF01AH    REF02AH</p> <p>REF01H    REF02H</p> <p>REF01EH    REF02EH</p> <p>REF01HH    REF02HH</p> <p>REF01CH    REF02CH</p> <p>REF02DH</p>	<p>REF01EN8    REF02EN8</p> <p>REF01HN8    REF02HN8</p> <p>REF01CN8    REF02CN8</p> <p>REF02DN8</p>		<p>REF01EJ8    REF02EJ8</p> <p>REF01HJ8    REF02HJ8</p> <p>REF01CJ8    REF02CJ8</p> <p>REF02DJ8</p>	
<p><b>OBSOLETE PACKAGE</b></p> <p>Consider the N Package for Alternate Source</p>		<p><b>OBSOLETE PACKAGE</b></p> <p>Consider the N Package for Alternate Source</p>			

Consult LTC Marketing for parts specified with wider operating temperature ranges.

## ELECTRICAL CHARACTERISTICS $V_{IN} = 15V$ , $T_A = 25^{\circ}C$ unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	REF-01A/E, REF-02A/E			REF-01H, REF-02H			UNITS		
			MIN	TYP	MAX	MIN	TYP	MAX			
$V_O$	Output Voltage	$I_L = 0mA$	REF-01	9.97	10	10.03	REF-01H	9.95	10	10.05	V
			REF-02	4.985	5	5.015	REF-02H	4.975	5	5.025	V
	Output Adjustment Range	$R_P = 10k\Omega$	REF-01	$\pm 3$	5, -27		REF-01H	$\pm 3$	5, -27		%
		REF-02	$\pm 3$	5, -13		REF-02H	$\pm 3$	5, -13		%	
$e_{nP-P}$	Output Voltage Noise	0.1Hz to 10Hz (Note 7)	REF-01	20		REF-01H	20			$\mu V_{P-P}$	
			REF-02	10		REF-02H	10			$\mu V_{P-P}$	
$V_{IN}$	Input Voltage Range		REF-01	12	40	REF-01H	12	40	V		
			REF-02	7	40	REF-02H	7	40	V		
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation (Note 2)	$(V_{OUT} + 3V) \leq V_{IN} \leq 33V$		0.0001	0.010		0.0001	0.010	%/V		
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation (Note 2)	$I_L = 0mA$ to 10mA	REF-01	0.0005	0.008	REF-01H	0.0005	0.010	%/mA		
			REF-02	0.0010	0.010	REF-02H	0.001	0.010	%/mA		
$I_Q$	Quiescent Supply Current	No Load		0.65	1.4		0.65	1.4	mA		
$I_{OUT}$	Load Current			10	20		10	20	mA		
				-0.3	-20		-0.3	-20	mA		
$I_{SC}$	Short-Circuit Current	$V_O = 0V$		25		25		mA			
$V_T$	Temperature Voltage Output	(Note 3)	REF-02 Only	620		620		mV			

## ELECTRICAL CHARACTERISTICS $V_{IN} = 15V$ , $T_A = 25^\circ C$ unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	REF-01C, REF-02C			REF-02D			UNITS	
			MIN	TYP	MAX	MIN	TYP	MAX		
$V_O$	Output Voltage	$I_L = 0mA$	REF-01 REF-02	9.9 4.95	10 5	10.1 5.05	4.9	5	5.1	V V
	Output Adjustment Range	$R_P = 10k\Omega$	REF-01 REF-02	$\pm 2.7$	5, -27 5, -13		$\pm 2$	5, -13		% %
$e_{nP-P}$	Output Voltage Noise	0.1Hz to 10Hz (Note 7)	REF-01 REF-02		30 12			12		$\mu V_{P-P}$ $\mu V_{P-P}$
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation (Note 2)	$(V_{OUT} + 3V) \leq V_{IN} \leq 33V$			0.0001	0.015		0.0001	0.04	%/V
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation (Note 2)	$I_L = 0mA$ to 8mA $I_L = 0mA$ to 4mA			0.0005	0.015		0.001	0.04	%/mA %/mA
$I_Q$	Quiescent Supply Current	No Load			0.65	1.6		0.65	2	mA
$I_{OUT}$	Load Current			8	20		8	20		mA
	Sink Current			-0.2	20		-0.2	20		mA
$I_{SC}$	Short-Circuit Current	$V_O = 0V$			25			25		mA
$V_T$	Temperature Voltage Output	(Note 3)	REF-02 Only		620			620		mV

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ C$ .  $V_{IN} = 15V$ ,  $-55^\circ C \leq T_A \leq \pm 125^\circ C$  for REF-01A/REF-02A and REF-01/REF-02,  $0^\circ C \leq T_A \leq 70^\circ C$  for REF-01E/REF-02E and REF-01H/REF-02H,  $I_L = 0mA$  unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		REF-01A/E, REF-02A/E			REF-01H/REF-02H			UNITS
				MIN	TYP	MAX	MIN	TYP	MAX	
$\frac{\Delta V}{\Delta T}$	Output Voltage Change with Temperature (Notes 4, 5)	$0^\circ C \leq T_A \leq 70^\circ C$	●		0.02	0.06		0.035	0.17	%
		$-55^\circ C \leq T_A \leq 125^\circ C$	●		0.09	0.15		0.144	0.45	%
TC	Output Voltage Temperature Coefficient	(Note 6)	●		5	8.5		8	25	ppm/ $^\circ C$
	Change in $V_O$ Temperature Coefficient with Output Adjustment	$R_P = 10k\Omega$	●		0.5			0.5		ppm/%
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation $(V_{OUT} + 3V) \leq V_{IN} \leq 33V$ (Note 2)	$0^\circ C \leq T_A \leq 70^\circ C$	●		0.0001	0.012		0.0001	0.012	%/V
		$-55^\circ C \leq T_A \leq 125^\circ C$	●		0.0001	0.015		0.0001	0.015	%/V
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation ( $I_L = 0mA$ to 8mA) (Note 2)	$0^\circ C \leq T_A \leq 70^\circ C$	●		0.002	0.010		0.002	0.012	%/mA
		$-55^\circ C \leq T_A \leq 125^\circ C$	●		0.002	0.012		0.002	0.015	%/mA
	Temperature Voltage Output Temperature Coefficient	(Note 3) REF-02	●		2.1			2.1		mV/ $^\circ C$

## ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V_{IN} = 15\text{V}$ ,  $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$  and  $I_L = 0\text{mA}$  unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		REF-01C, REF-02C			REF-02D			UNITS
				MIN	TYP	MAX	MIN	TYP	MAX	
$\frac{\Delta V}{\Delta T}$	Output Voltage Change with Temperature	(Notes 4, 5)	●			0.45			1.7	%
TC	Output Voltage Temperature Coefficient	(Note 6)	●		8	65		8	250	ppm/ $^\circ\text{C}$
	Change in $V_O$ Temperature Coefficient with Output Adjustment	$R_P = 10\text{k}\Omega$	●		0.5			0.5		ppm/%
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation (Note 2)	$V_{IN} = 8\text{V to } 30\text{V}$	●		0.0001	0.018		0.0001	0.05	%/V
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation (Note 2)	$I_L = 0\text{mA to } 5\text{mA}$	●		0.002	0.018		0.002	0.05	%/mA
	Temperature Voltage Output Temperature Coefficient	(Note 3) REF-02	●		2.1			2.1		mV/ $^\circ\text{C}$

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**Note 2:** Line and load regulation specifications include the effect of self heating.

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

**Note 4:**  $\Delta V$  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 nominal output.

$$\Delta V = \left| \frac{V_{MAX} - V_{MIN}}{V_{OUT}} \right| \cdot 100$$

**Note 5:**  $\Delta V$  specification applies trimmed or untrimmed.

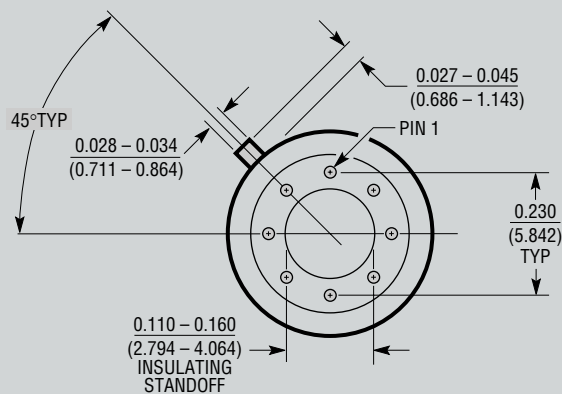
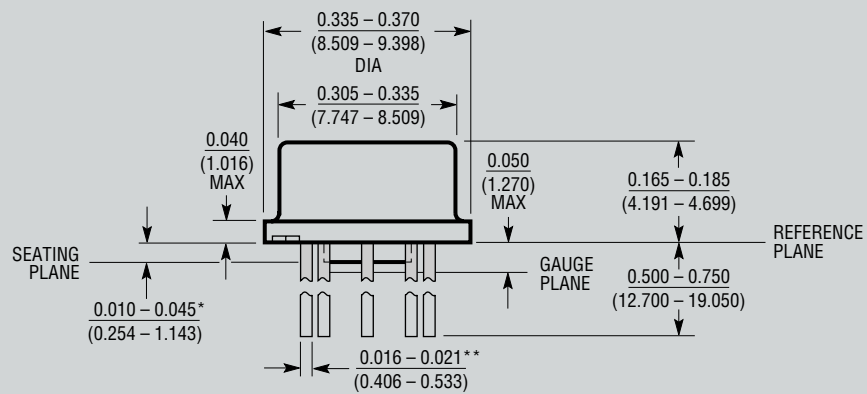
**Note 6:** TC is defined as  $\Delta V$  divided by the temperature range, i.e.,

$$TC = \frac{\Delta V}{T_{MAX} - T_{MIN}}$$

**Note 7:** 0.1Hz to 10Hz noise cannot be 100% tested on modern high speed test equipment, so Linear Technology does not put a guaranteed maximum specification on this parameter for standard units. 100% bench testing of 0.1Hz to 10Hz noise is available on special request. To ensure low output noise, Linear Technology *does* 100% test 10Hz to 1kHz noise. Consult factory for details.

## PACKAGE DESCRIPTION

**H Package**  
**8-Lead TO-5 Metal Can (.230 Inch PCD)**  
 (Reference LTC DWG # 05-08-1321)



\* LEAD DIAMETER IS UNCONTROLLED BETWEEN THE REFERENCE PLANE AND 0.045" BELOW THE REFERENCE PLANE

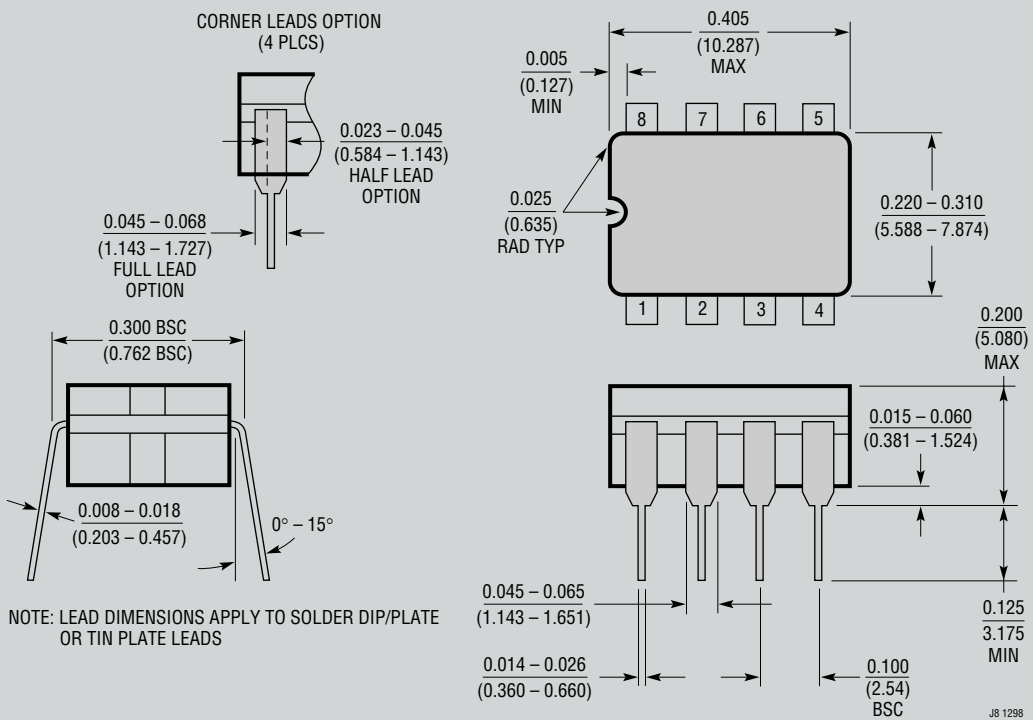
\*\* FOR SOLDER DIP LEAD FINISH, LEAD DIAMETER IS  $0.016 - 0.024$  (0.406 - 0.610)

H8 (TO-5) 0.230 PCD 1197

**OBSELETE PACKAGE**

**PACKAGE DESCRIPTION**

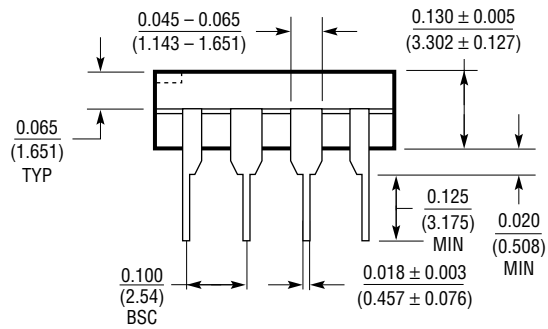
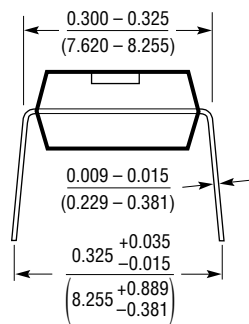
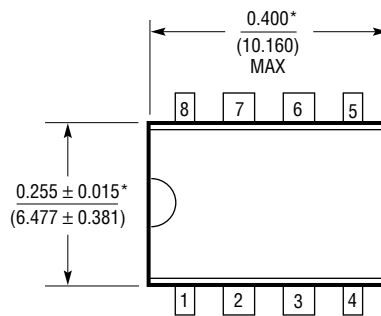
**J8 Package**  
**8-Lead CERDIP (Narrow .300 Inch, Hermetic)**  
 (Reference LTC DWG # 05-08-1110)



**OBSOLETE PACKAGE**

## PACKAGE DESCRIPTION

**N8 Package**  
**8-Lead PDIP (Narrow .300 Inch)**  
 (Reference LTC DWG # 05-08-1510)



\*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.  
 MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm)

N8 1098

# REF-01/REF-02

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## RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1019	0.05%, 5ppm/°C Precision Reference	Pin Compatible with the REF-01, REF-02, Improved Specs