

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.

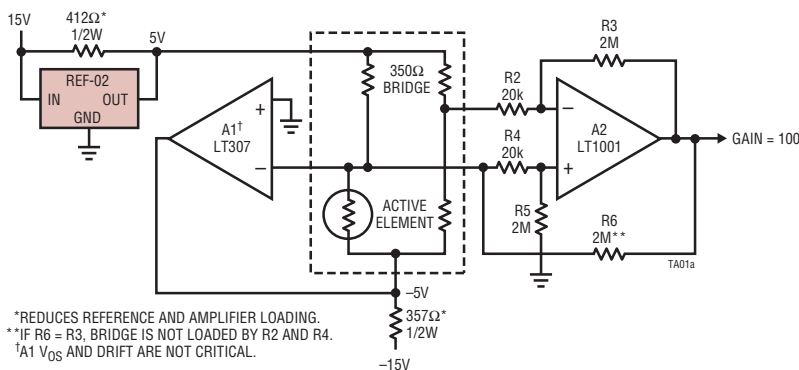
The REF-02 includes a temperature output pin which provides a linear voltage proportional to absolute temperature.

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

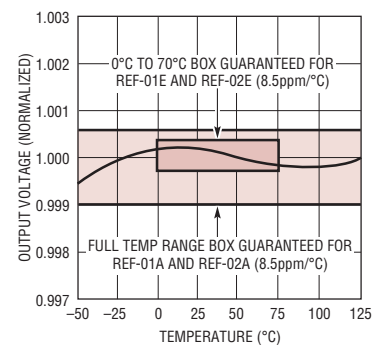
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TYPICAL APPLICATION

Ultra Linear Strain Gauge Amplifier



Output Voltage Temperature Drift



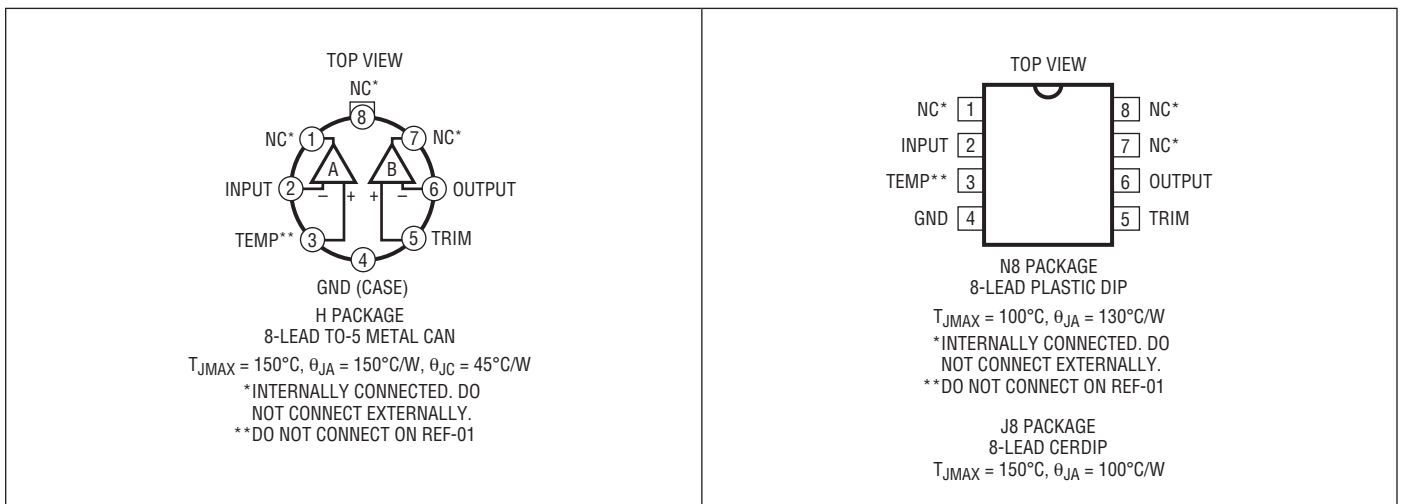
REF-01/REF-02

ABSOLUTE MAXIMUM RATINGS

REF-01/REF-02 A, E, H 40V
 REF-01C/REF-02C 30V
 Power Dissipation 500mW
 Output Short-Circuit Duration
 To Ground Indefinite
 To $V_{IN} \leq 16V$ Indefinite
 To $V_{IN} > 16V$ Not Allowed

Storage Temperature Range -65°C to 150°C
 Operating Temperature
 REF-01/REF-02, REF-01A/REF-02A... -55°C to 125°C
 REF-01E/REF-02E, REF-01H/REF-02H,
 REF-01C/REF-02C, REF-01D/REF-02D 0°C to 70°C
 Lead Temperature (Soldering, 10 sec)..... 300°C

PIN CONFIGURATION



ORDER INFORMATION

| LEAD FREE FINISH | PART MARKING | PACKAGE DESCRIPTION | TEMPERATURE RANGE |
|------------------|--------------|-----------------------|-------------------|
| REF01EN8#PBF | REF01EN8 | 8-Lead Plastic Dip | 0°C to 70°C |
| REF01HN8#PBF | REF01HN8 | 8-Lead Plastic Dip | 0°C to 70°C |
| REF01CN8#PBF | REF01CN8 | 8-Lead Plastic Dip | 0°C to 70°C |
| REF02EN8#PBF | REF02EN8 | 8-Lead Plastic Dip | 0°C to 70°C |
| REF02HN8#PBF | REF02HN8 | 8-Lead Plastic Dip | 0°C to 70°C |
| REF02CN8#PBF | REF02CN8 | 8-Lead Plastic Dip | 0°C to 70°C |
| REF02DN8#PBF | REF02DN8 | 8-Lead Plastic Dip | 0°C to 70°C |
| REF01AH#PBF | | 8-Lead TO-5 Metal Can | -55°C to 125°C |
| REF01H#PBF | | 8-Lead TO-5 Metal Can | -55°C to 125°C |
| REF01EH#PBF | | 8-Lead TO-5 Metal Can | 0°C to 70°C |
| REF01HH#PBF | | 8-Lead TO-5 Metal Can | 0°C to 70°C |
| REF01CH#PBF | | 8-Lead TO-5 Metal Can | 0°C to 70°C |
| REF02H#PBF | | 8-Lead TO-5 Metal Can | -55°C to 125°C |
| REF02EH#PBF | | 8-Lead TO-5 Metal Can | 0°C to 70°C |
| REF02HH#PBF | | 8-Lead TO-5 Metal Can | 0°C to 70°C |
| REF02CH#PBF | | 8-Lead TO-5 Metal Can | 0°C to 70°C |

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ORDER INFORMATION

| LEAD FREE FINISH | PART MARKING | PACKAGE DESCRIPTION | TEMPERATURE RANGE |
|--|--------------|-----------------------|-------------------|
| REF02DH#PBF | | 8-Lead TO-5 Metal Can | 0°C to 70°C |
| REF01EJ8#PBF | | 8-Lead Cerdip | 0°C to 70°C |
| REF01HJ8#PBF | | 8-Lead Cerdip | 0°C to 70°C |
| REF01CJ8#PBF | | 8-Lead Cerdip | 0°C to 70°C |
| REF02EJ8#PBF | | 8-Lead Cerdip | 0°C to 70°C |
| REF02HJ8#PBF | | 8-Lead Cerdip | 0°C to 70°C |
| REF02CJ8#PBF | | 8-Lead Cerdip | 0°C to 70°C |
| REF02DJ8#PBF | | 8-Lead Cerdip | 0°C to 70°C |
| OBsolete Consider the N Package for Alternate Source | | | |
| LEAD BASED FINISH | PART MARKING | PACKAGE DESCRIPTION | TEMPERATURE RANGE |
| REF02AH | REF02AH | 8-Lead TO-5 Metal Can | -55°C to 125°C |
| REF02AJ8 | REF02AJ8 | 8-Lead Cerdip | -55°C to 125°C |

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

For more information on lead free part marking, go to: <http://www.linear.com/leadfree/>

For more information on tape and reel specifications, go to: <http://www.linear.com/tapeandree/>

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 REF-02 | 9.97 4.985 | 10 5 | 10.03 5.015 | 9.95 4.975 | 10 5 | 10.05 5.025 | V V | |
| | Output Adjustment Range | $R_p = 10k\Omega$ | REF-01 REF-02 | ± 3 ± 3 | 5, -27 5, -13 | | ± 3 ± 3 | 5, -27 5, -13 | | % % | |
| e_{n-P-P} | Output Voltage Noise | 0.1Hz to 10Hz (Note 7) | REF-01 REF-02 | | 20 10 | | | 20 10 | | μV_{P-P} μV_{P-P} | |
| V_{IN} | Input Voltage Range | | REF-01 | 12 | | 40 | 12 | | 40 | V V | |
| | | | REF-02 | 7 | | 40 | 7 | | 40 | | |
| $\frac{\Delta V_{OUT}}{\Delta V_{IN}}$ | Line Regulation (Note 2) | $(V_{OUT} + 3V) \leq V_{IN} \leq 33V$ | | | 0.0001 | 0.01 | | | 0.0001 | 0.01 | %/V |
| $\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$ | Load Regulation (Note 2) | $I_L = 0mA$ to 10mA | REF-01 | | 0.0005 | 0.008 | | | 0.0005 | 0.01 | %/mA %/mA |
| | | | REF-02 | | 0.001 | 0.01 | | | 0.001 | 0.01 | |
| I_Q | Quiescent Supply Current | No Load | | | 0.65 | 1.4 | | | 0.65 | 1.4 | mA |
| I_{OUT} | Load Current Sink Current | | | 10 | 20 | | 10 | 20 | | | mA mA |
| | | | | -0.3 | -20 | | -0.3 | -20 | | | |
| I_{SC} | Short-Circuit Current | $V_O = 0V$ | | | 25 | | | | 25 | | mA |
| V_T | Temperature Voltage Output (Note 3) | | REF-02 Only | | 620 | | | | 620 | | mV |

$V_{IN} = 15V, T_A = 25^\circ C$ 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 | ± 2.7 | 5, -27 5, -13 | | ± 2 | 5, -13 | | % % |
| e_{n-P-P} | Output Voltage Noise | 0.1Hz to 10Hz (Note 7) | REF-01 REF-02 | | 30 12 | | | 12 | | μV_{P-P} μV_{P-P} |

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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 | |
| $\frac{\Delta V_{OUT}}{\Delta V_{IN}}$ | 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 Sink Current | | 8 -0.2 | 20 20 | | 8 -0.2 | 20 20 | | mA 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 | 0.01 | | 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/ $^\circ C$ |

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^\circ C$.
 $V_{IN} = 15V$, $0^\circ C \leq T_A \leq 70^\circ C$ and $I_L = 0mA$ 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/ $^\circ C$ |
| | | 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 (Note 2) | $V_{IN} = 8V$ to 30V | ● | | 0.0001 | 0.018 | | 0.0001 | 0.05 | %/V |
| $\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$ | Load Regulation (Note 2) | $I_L = 0mA$ to 5mA | ● | | 0.002 | 0.018 | | 0.002 | 0.05 | %/mA |
| | | Temperature Voltage Output Temperature Coefficient | (Note 3) REF-02 | ● | | 2.1 | | | 2.1 | |

ELECTRICAL CHARACTERISTICS

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

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: ΔV 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: ΔV specification applies trimmed or untrimmed.

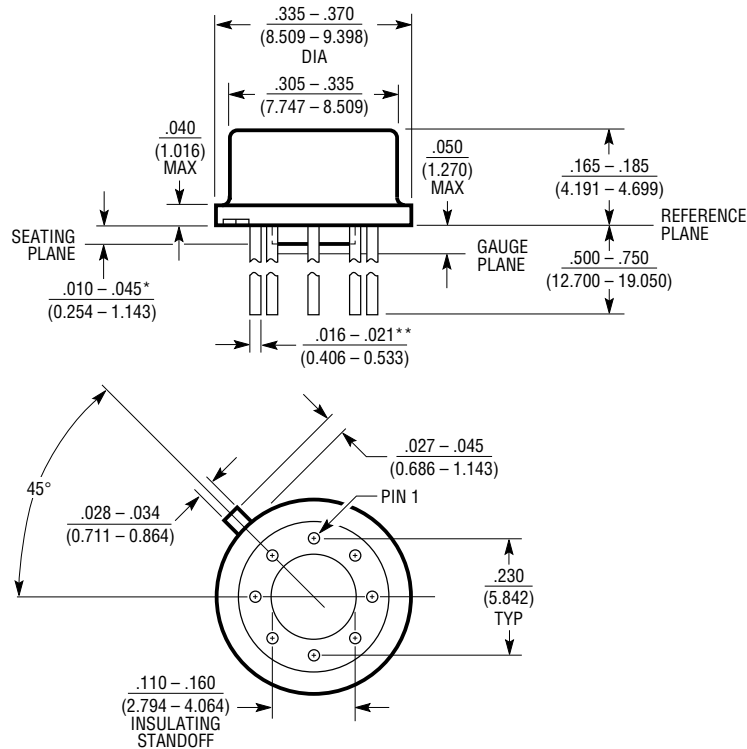
Note 6: TC is defined as ΔV divided by the temperature range, i.e.,

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

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)

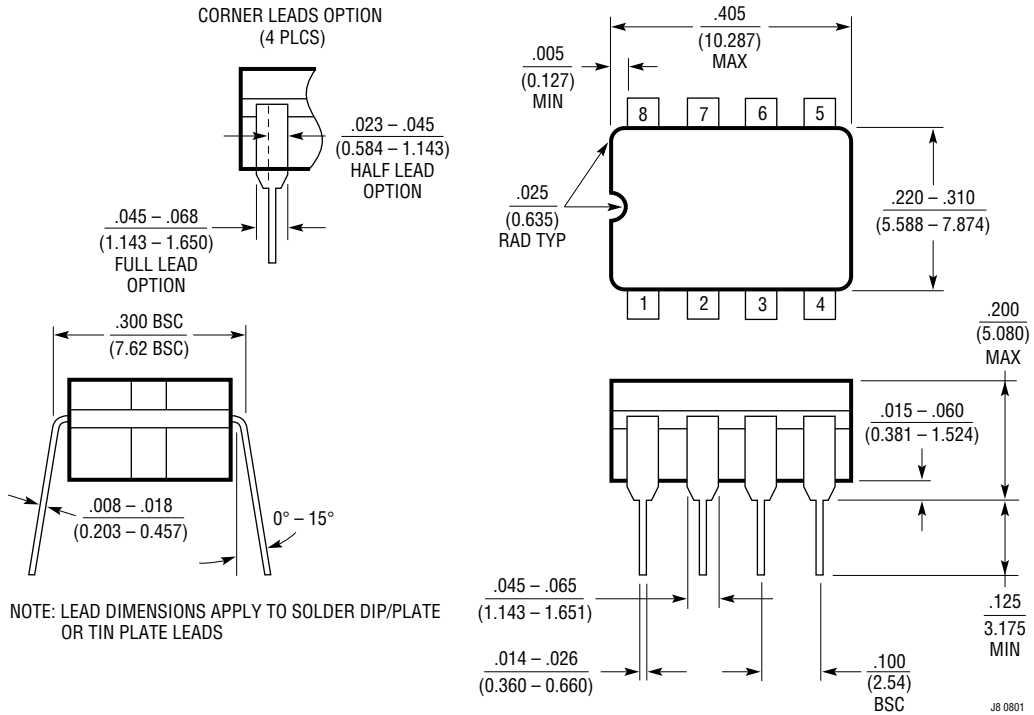


*LEAD DIAMETER IS UNCONTROLLED BETWEEN THE REFERENCE PLANE AND THE SEATING PLANE

** FOR SOLDER DIP LEAD FINISH, LEAD DIAMETER IS $\frac{.016 - .024}{(0.406 - 0.610)}$ H8 (TO-5) 0.230 PCD 0204

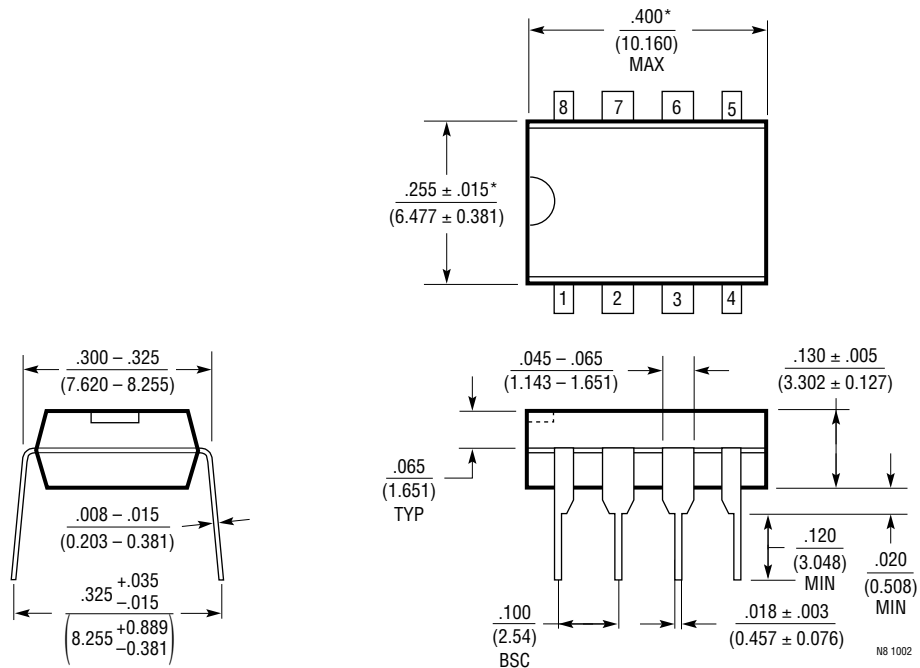
PACKAGE DESCRIPTION

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



PACKAGE DESCRIPTION

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



NOTE:

1. DIMENSIONS ARE $\frac{\text{INCHES}}{\text{MILLIMETERS}}$

*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH (0.254mm)

REF-01/REF-02

RELATED PARTS

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

