

## FEATURES

- Excellent Temperature Stability
- Initial Tolerance...0.2% Max
- Dynamic Impedance...0.6  $\Omega$  Max
- Wide Operating Current Range
- Directly Interchangeable With LM136
- Needs No Adjustment for Minimum Temperature Coefficient

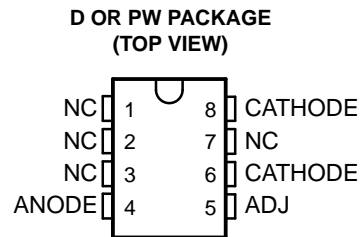
## DESCRIPTION/ORDERING INFORMATION

The LT1009 reference circuit is a precision-trimmed 2.5-V shunt regulator featuring low dynamic impedance and a wide operating current range. The maximum initial tolerance is  $\pm 5$  mV in the LP package and  $\pm 10$  mV in the D package. The reference tolerance is achieved by on-chip trimming, which minimizes the initial voltage tolerance and the temperature coefficient,  $\alpha_{VZ}$ .

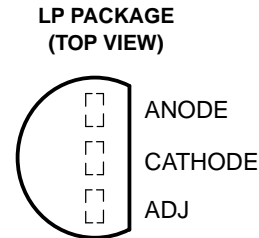
Although the LT1009 needs no adjustments, a third terminal (ADJ) allows the reference voltage to be adjusted  $\pm 5\%$  to eliminate system errors. In many applications, the LT1009 can be used as a terminal-for-terminal replacement for the LM136-2.5, which eliminates the external trim network.

The LT1009 uses include 5-V system references, 8-bit analog-to-digital converter (ADC) and digital-to-analog converter (DAC) references, and power-supply monitors. The device also can be used in applications such as digital voltmeters and current-loop measurement and control systems.

The LT1009C is characterized for operation from 0°C to 70°C. The LT1009I is characterized for operation from -40°C to 85°C.



NC – No internal connection



## ORDERING INFORMATION

| T <sub>A</sub> | PACKAGE <sup>(1)</sup> |              | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|------------------------|--------------|-----------------------|------------------|
| 0°C to 70°C    | SOIC – D               | Tube of 75   | LT1009CD              | 1009C            |
|                |                        | Reel of 2500 | LT1009CDR             |                  |
|                | TO-226/TO-92 – LP      | Bulk of 1000 | LT1009CLP             | LT1009C          |
|                |                        | Ammo of 2000 | LT1009CLPM            |                  |
|                |                        | Reel of 2000 | LT1009CLPR            |                  |
|                | TSSOP – PW             | Tube of 150  | LT1009CPW             | 1009C            |
| Reel of 2000   |                        | LT1009CPWR   |                       |                  |
| -40°C to 85°C  | SOIC – D               | Tube of 75   | LT1009ID              | 1009I            |
|                |                        | Reel of 2500 | LT1009IDR             |                  |
|                | TO-226/TO-92 – LP      | Bulk of 1000 | LT1009ILP             | LT1009I          |
|                |                        | Ammo of 2000 | LT1009ILPM            |                  |
|                |                        | Reel of 2000 | LT1009ILPR            |                  |
|                | TSSOP – PW             | Tube of 150  | LT1009IPW             | 1009I            |
|                |                        | Reel of 2000 | LT1009IPWR            |                  |

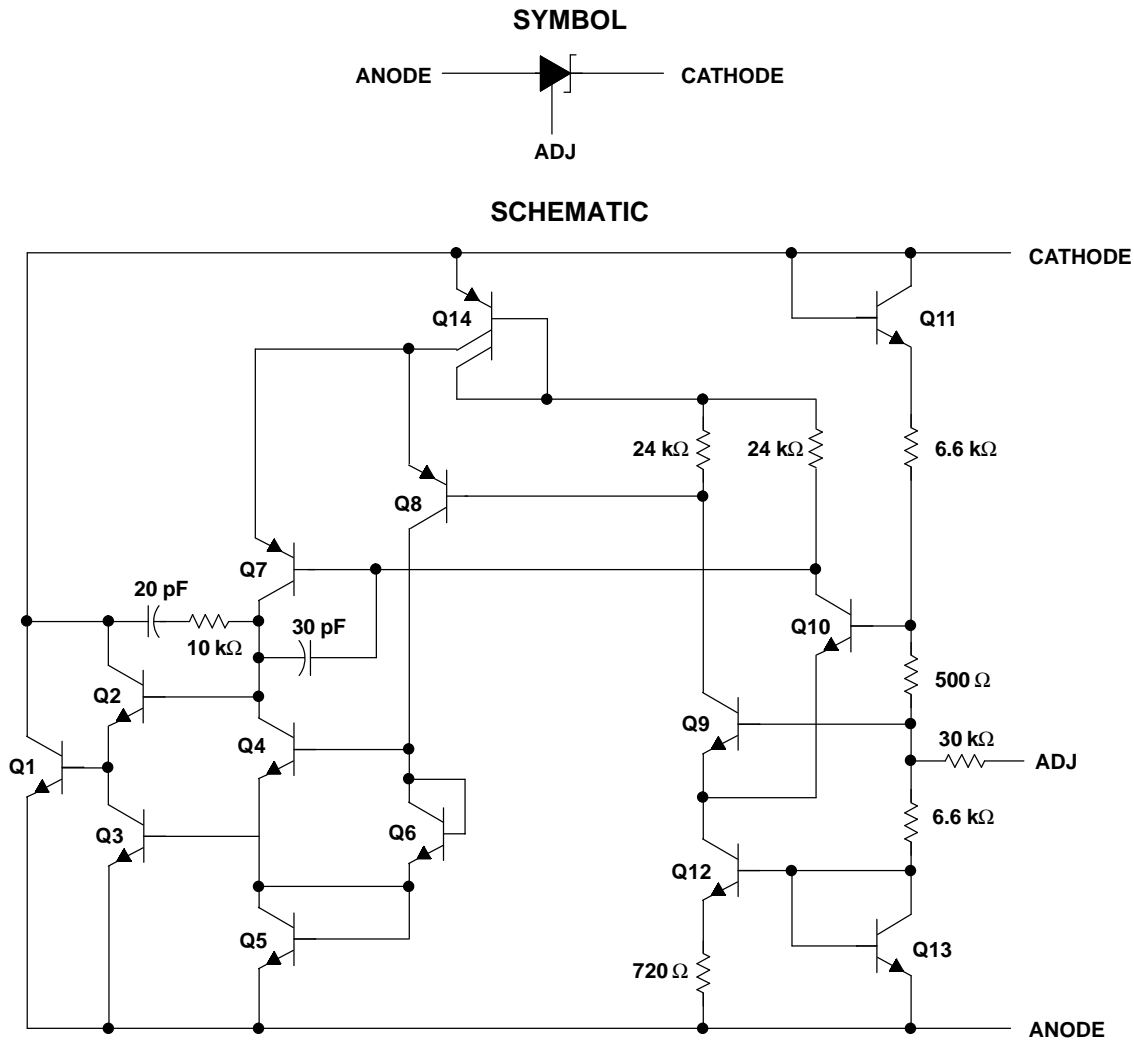
(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

# LT1009 2.5-V INTEGRATED REFERENCE CIRCUIT

SLVS013L–MAY 1987–REVISED SEPTEMBER 2005



NOTE: All component values shown are nominal.

## Absolute Maximum Ratings<sup>(1)</sup>

over operating free-air temperature range (unless otherwise noted)

|               |   | MIN        | MAX | UNIT |
|---------------|---|------------|-----|------|
| $I_R$         | Reverse current                             |            | 20  | mA   |
| $I_F$         | Forward current                             |            | 10  | mA   |
| $\theta_{JA}$ | Package thermal impedance <sup>(2)(3)</sup> |            | 97  | °C/W |
|               |   | D package  |     |      |
|               |   | LP package | 140 |      |
|               | PW package                                  |            | 149 |      |
| $T_J$         | Operating virtual junction temperature      |            | 150 | °C   |
| $T_{stg}$     | Storage temperature range                   | -65        | 150 | °C   |

- (1) 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 under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) Maximum power dissipation is a function of  $T_J(\text{max})$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(\text{max}) - T_A)/\theta_{JA}$ . Operating at the absolute maximum  $T_J$  of 150°C can affect reliability.
- (3) The package thermal impedance is calculated in accordance with JESD 51-7.

### Recommended Operating Conditions

|       |                                      | MIN     | MAX | UNIT |    |
|-------|--------------------------------------|---------|-----|------|----|
| $T_A$ | Operating free-air temperature range | LT1009C | 0   | 70   | °C |
|       |                                      | LT1009I | –40 | 85   |    |

### Electrical Characteristics

at specified free-air temperature

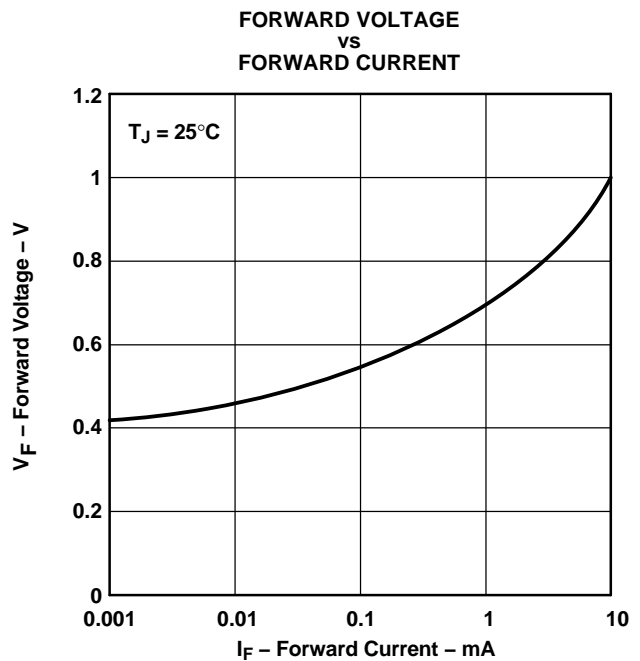
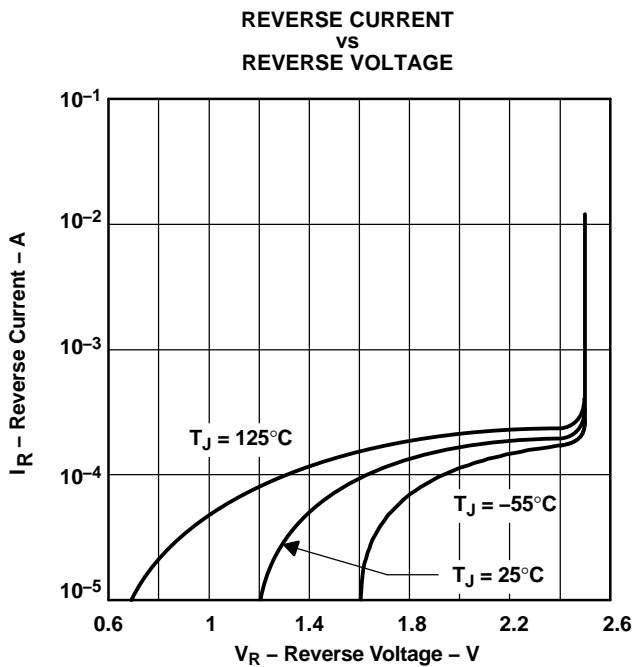
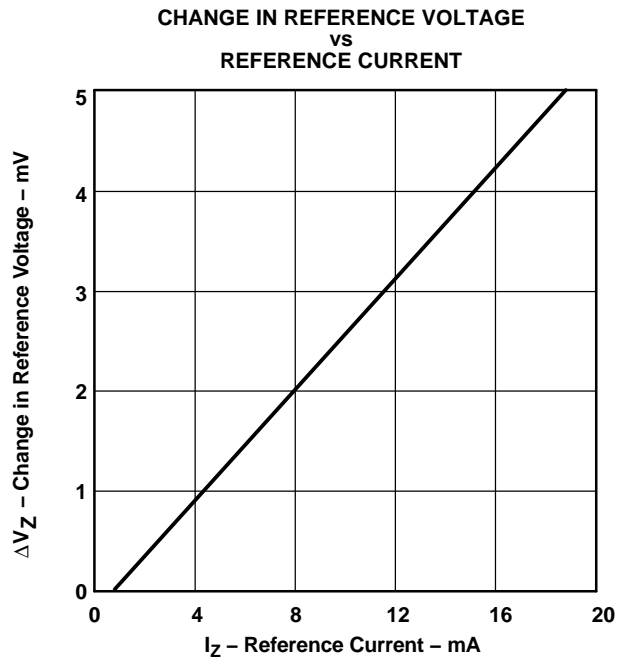
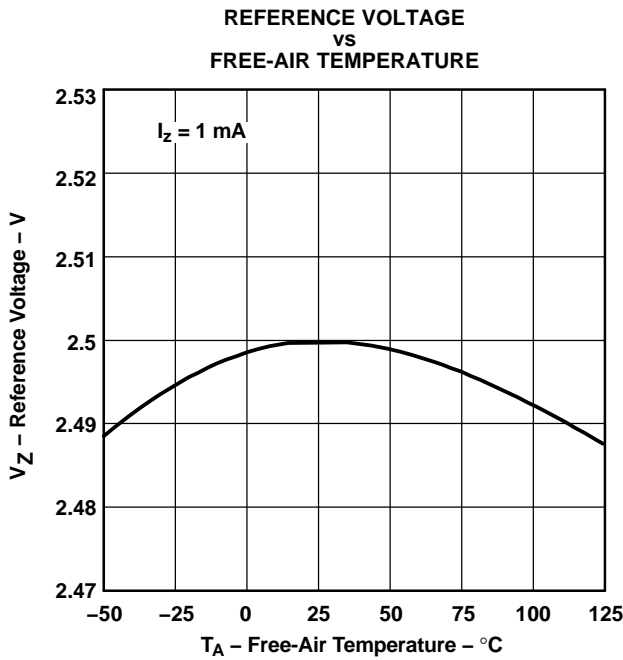
| PARAMETER                   | TEST CONDITIONS   | $T_A$ <sup>(1)</sup>   | LT1009C       |       |       | LT1009I |       |       | UNIT  |          |     |
|-----------------------------|---|--|---------------|-------|-------|---------|-------|-------|-------|----------|-----|
|                             |   |  | MIN           | TYP   | MAX   | MIN     | TYP   | MAX   |       |          |     |
| $V_Z$                       | Reference voltage   | $I_Z = 1\text{ mA}$  | D package     | 25°C  | 2.49  | 2.5     | 2.51  | 2.49  | 2.5   | 2.51     | V   |
|                             |   |  | LP package    |       | 2.495 | 2.5     | 2.505 | 2.495 | 2.5   | 2.505    |     |
|                             |   | Full range   | D package     | 2.485 |       | 2.515   | 2.475 |       | 2.525 |          |     |
|                             |   |  | LP package    | 2.491 |       | 2.509   | 2.48  |       | 2.52  |          |     |
| $V_F$                       | Forward voltage   | $I_F = 2\text{ mA}$  | 25°C          | 0.4   |       | 1       | 0.4   |       | 1     | V        |     |
|                             | Adjustment range  | $I_Z = 1\text{ mA}$ ,<br>$V_{ADJ} = \text{GND to } V_Z$                  | 25°C          | 125   |       |         | 125   |       |       | mV       |     |
|                             |   | $I_Z = 1\text{ mA}$ ,<br>$V_{ADJ} = 0.6\text{ V to } V_Z - 0.6\text{ V}$ |               | 45    |       |         | 45    |       |       |          |     |
| $\Delta V_{Z(\text{temp})}$ | Change in reference voltage with temperature                        | D package  | Full range    | 5     |       |         | 15    |       |       | mV       |     |
|                             |   | LP package   |               | 4     |       |         | 15    |       |       |          |     |
| $\alpha_{V_Z}$              | Average temperature coefficient of reference voltage <sup>(2)</sup> |  | 0°C to 70°C   | 15    |       |         | 25    |       |       | ppm/°C   |     |
|                             |   |  | –40°C to 85°C |       |       |         | 20    |       |       |          | 35  |
| $\Delta V_Z$                | Change in reference voltage with current                            | $I_Z = 400\text{ }\mu\text{A to } 10\text{ mA}$                          | 25°C          | 2.6   |       |         | 10    |       |       | mV       |     |
|                             |   |  | Full range    |       |       |         | 12    |       |       |          | 10  |
| $\Delta V_Z/\Delta t$       | Long-term change in reference voltage                               | $I_Z = 1\text{ mA}$  | 25°C          | 20    |       |         | 20    |       |       | ppm/khr  |     |
| $Z_Z$                       | Reference impedance   | $I_Z = 1\text{ mA}$  | 25°C          | 0.3   |       |         | 1     |       |       | $\Omega$ |     |
|                             |   |  | Full range    |       |       |         | 1.4   |       |       |          | 1.4 |

(1) Full range is 0°C to 70°C for the LT1009C and –40°C to 85°C for the LT1009I.

(2) The average temperature coefficient of reference voltage is defined as the total change in reference voltage divided by the specified temperature range.

TYPICAL CHARACTERISTICS

Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.



**TYPICAL CHARACTERISTICS (continued)**

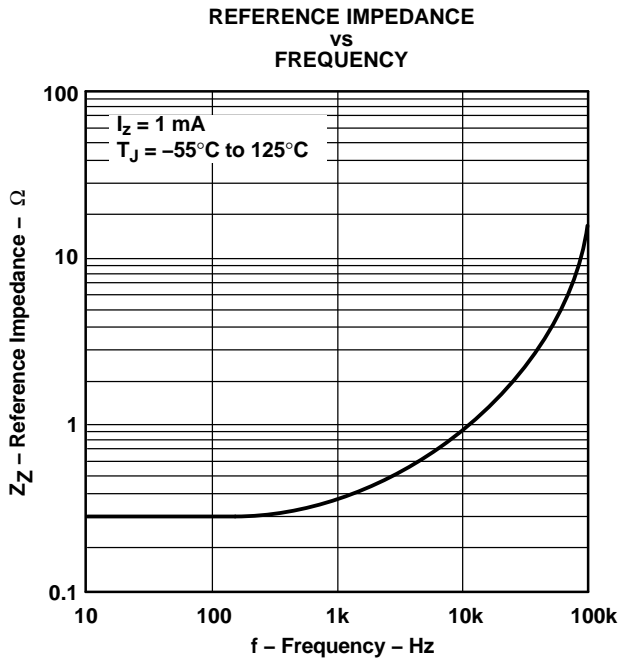


Figure 5.

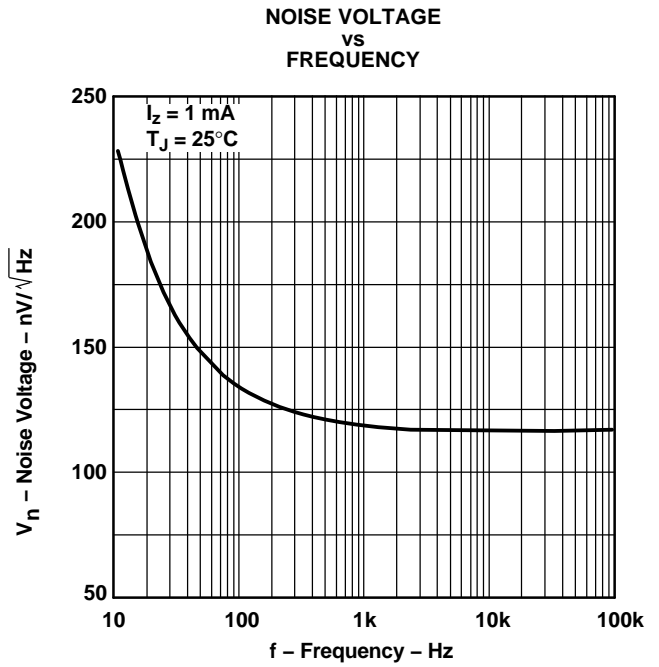


Figure 6.

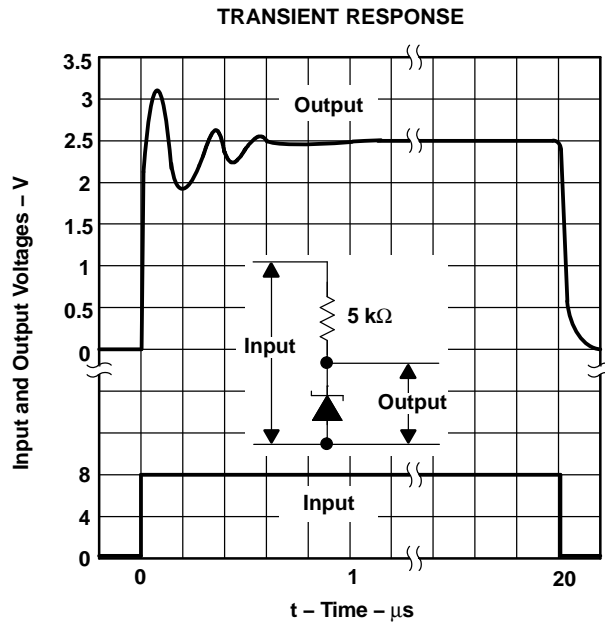
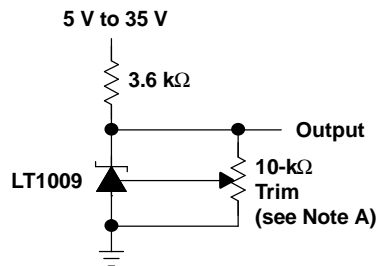


Figure 7.

APPLICATION INFORMATION



A. This does not affect temperature coefficient. It provides  $\pm 5\%$  trim range.

Figure 8. 2.5-V Reference

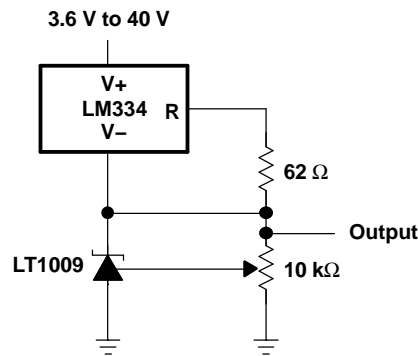


Figure 9. Adjustable Reference With Wide Supply Range

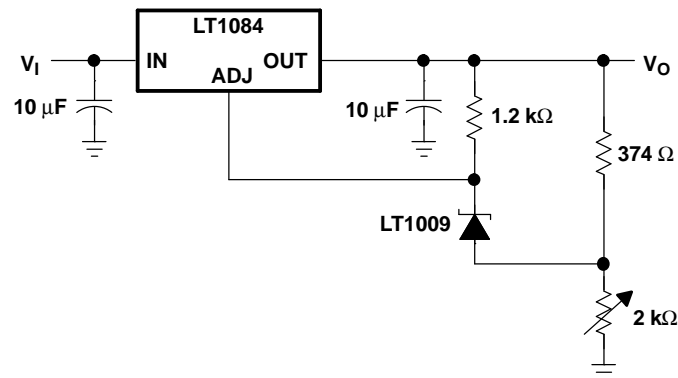
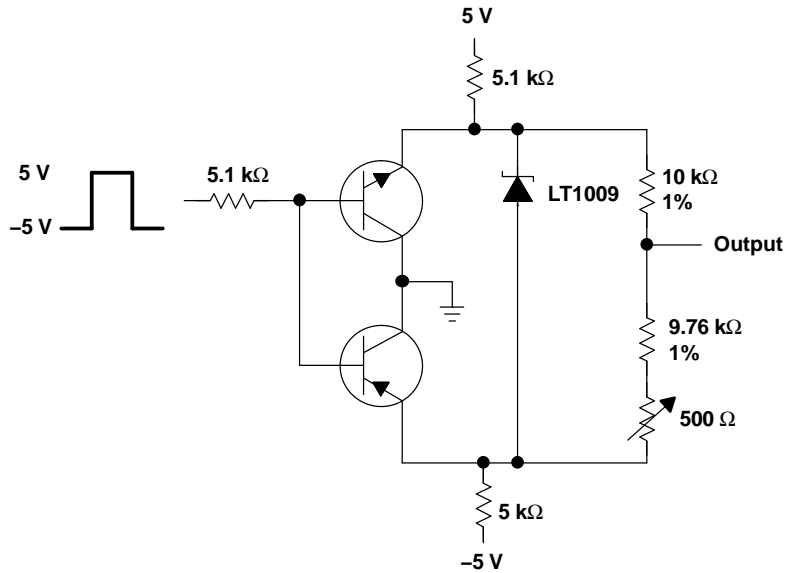
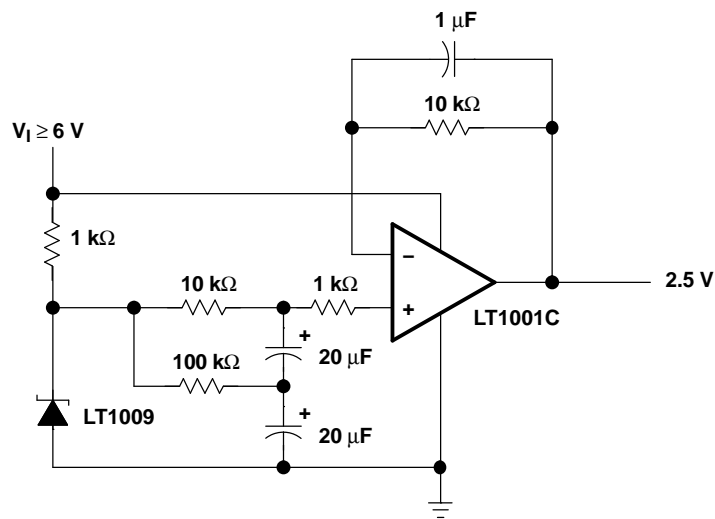


Figure 10. Power Regulator With Low Temperature Coefficient

**APPLICATION INFORMATION (continued)**



**Figure 11. Switchable  $\pm 1.25$ -V Bipolar Reference**



**Figure 12. Low-Noise 2.5-V Buffered Reference**

**PACKAGING INFORMATION**

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup> |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| LT1009CD         | ACTIVE                | SOIC         | D               | 8    | 75          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009CDE4       | ACTIVE                | SOIC         | D               | 8    | 75          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009CDR        | ACTIVE                | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009CDRE4      | ACTIVE                | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009CDRG4      | ACTIVE                | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009CLP        | ACTIVE                | TO-92        | LP              | 3    | 1000        | TBD                     | CU SNPB          | Level-NC-NC-NC               |
| LT1009CLPM       | ACTIVE                | TO-92        | LP              | 3    | 2000        | TBD                     | CU SNPB          | Level-NC-NC-NC               |
| LT1009CLPR       | ACTIVE                | TO-92        | LP              | 3    | 2000        | TBD                     | CU SNPB          | Level-NC-NC-NC               |
| LT1009CPK        | OBSOLETE              | SOT-89       | PK              | 3    |             | TBD                     | Call TI          | Call TI                      |
| LT1009CPW        | ACTIVE                | TSSOP        | PW              | 8    | 150         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009CPWE4      | ACTIVE                | TSSOP        | PW              | 8    | 150         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009CPWR       | ACTIVE                | TSSOP        | PW              | 8    | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009CPWRE4     | ACTIVE                | TSSOP        | PW              | 8    | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009ID         | ACTIVE                | SOIC         | D               | 8    | 75          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009IDE4       | ACTIVE                | SOIC         | D               | 8    | 75          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009IDR        | ACTIVE                | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009IDRE4      | ACTIVE                | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009ILP        | ACTIVE                | TO-92        | LP              | 3    | 1000        | TBD                     | CU SNPB          | Level-NC-NC-NC               |
| LT1009ILPR       | ACTIVE                | TO-92        | LP              | 3    | 2000        | TBD                     | CU SNPB          | Level-NC-NC-NC               |
| LT1009IPW        | ACTIVE                | TSSOP        | PW              | 8    | 150         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009IPWE4      | ACTIVE                | TSSOP        | PW              | 8    | 150         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009IPWR       | ACTIVE                | TSSOP        | PW              | 8    | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009IPWRE4     | ACTIVE                | TSSOP        | PW              | 8    | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009QDR        | OBSOLETE              | SOIC         | D               | 8    |             | TBD                     | Call TI          | Call TI                      |
| LT1009Y          | OBSOLETE              | XCEPT        | Y               | 0    |             | TBD                     | Call TI          | Call TI                      |

<sup>(1)</sup> The marketing status values are defined as follows:

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(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS) or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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**PACKAGING INFORMATION**

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup> |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| LT1009CD         | ACTIVE                | SOIC         | D               | 8    | 75          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009CDE4       | ACTIVE                | SOIC         | D               | 8    | 75          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009CDR        | ACTIVE                | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009CDRE4      | ACTIVE                | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009CDRG4      | ACTIVE                | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009CLP        | ACTIVE                | TO-92        | LP              | 3    | 1000        | Pb-Free (RoHS)          | CU SN            | N / A for Pkg Type           |
| LT1009CLPE3      | ACTIVE                | TO-92        | LP              | 3    | 1000        | Pb-Free (RoHS)          | CU SN            | N / A for Pkg Type           |
| LT1009CLPM       | ACTIVE                | TO-92        | LP              | 3    | 2000        | Pb-Free (RoHS)          | CU SN            | N / A for Pkg Type           |
| LT1009CLPME3     | ACTIVE                | TO-92        | LP              | 3    | 2000        | Pb-Free (RoHS)          | CU SN            | N / A for Pkg Type           |
| LT1009CLPR       | ACTIVE                | TO-92        | LP              | 3    | 2000        | Pb-Free (RoHS)          | CU SN            | N / A for Pkg Type           |
| LT1009CLPRE3     | ACTIVE                | TO-92        | LP              | 3    | 2000        | Pb-Free (RoHS)          | CU SN            | N / A for Pkg Type           |
| LT1009CPK        | OBSOLETE              | SOT-89       | PK              | 3    |             | TBD                     | Call TI          | Call TI                      |
| LT1009CPW        | ACTIVE                | TSSOP        | PW              | 8    | 150         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009CPWE4      | ACTIVE                | TSSOP        | PW              | 8    | 150         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009CPWR       | ACTIVE                | TSSOP        | PW              | 8    | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009CPWRE4     | ACTIVE                | TSSOP        | PW              | 8    | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
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| LT1009IDE4       | ACTIVE                | SOIC         | D               | 8    | 75          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
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| LT1009ILPE3      | ACTIVE                | TO-92        | LP              | 3    | 1000        | Pb-Free (RoHS)          | CU SN            | N / A for Pkg Type           |
| LT1009ILPR       | ACTIVE                | TO-92        | LP              | 3    | 2000        | Pb-Free (RoHS)          | CU SN            | N / A for Pkg Type           |
| LT1009ILPRE3     | ACTIVE                | TO-92        | LP              | 3    | 2000        | Pb-Free (RoHS)          | CU SN            | N / A for Pkg Type           |
| LT1009IPW        | ACTIVE                | TSSOP        | PW              | 8    | 150         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |

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|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| LT1009IPWE4      | ACTIVE                | TSSOP        | PW              | 8    | 150         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009IPWR       | ACTIVE                | TSSOP        | PW              | 8    | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| LT1009IPWRE4     | ACTIVE                | TSSOP        | PW              | 8    | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
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| LT1009Y          | OBSOLETE              | XCEPT        | Y               | 0    |             | TBD                     | Call TI          | Call TI                      |

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**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

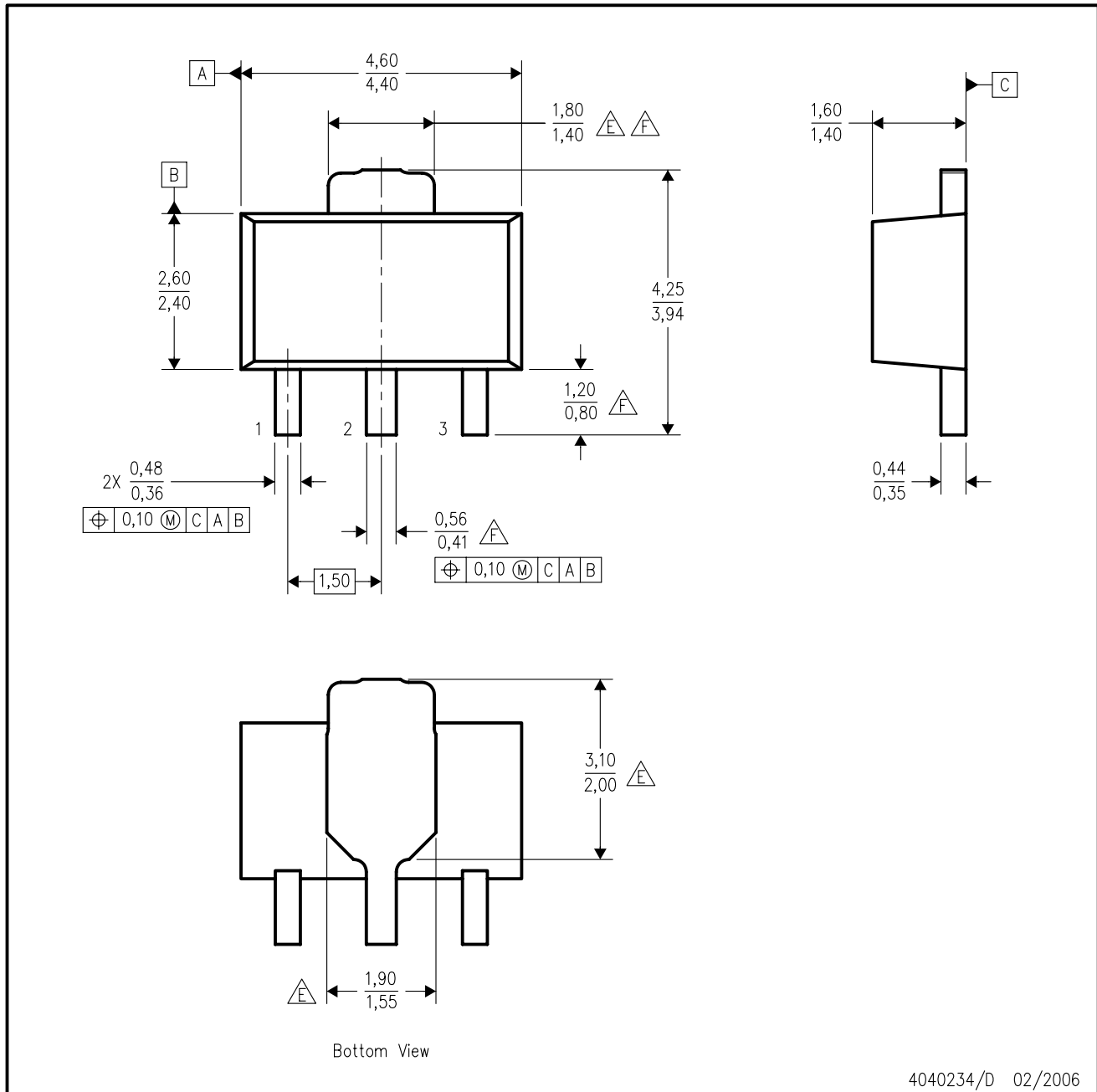
<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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PK (R-PSS0-F3)

PLASTIC SINGLE-IN-LINE PACKAGE

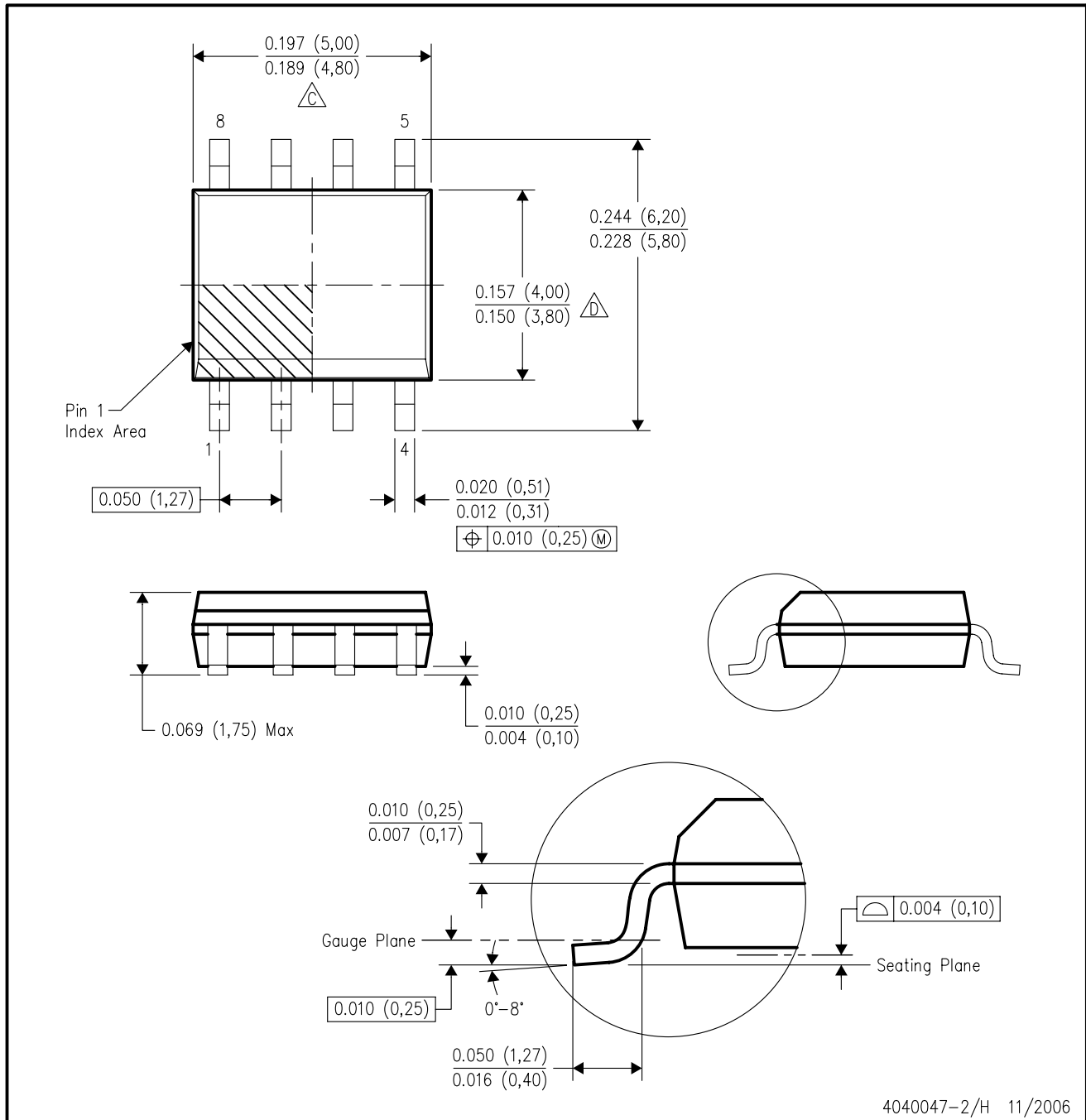


4040234/D 02/2006

- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - This drawing is subject to change without notice.
  - The center lead is in electrical contact with the tab.
  - Body dimensions do not include mold flash or protrusion. Mold flash and protrusion not to exceed 0.15 per side.
- △E Thermal pad contour optional within these dimensions.
- △F Falls within JEDEC TO-243 variation AA, except minimum lead length, pin 2 minimum lead width, minimum tab width.

D (R-PDSO-G8)

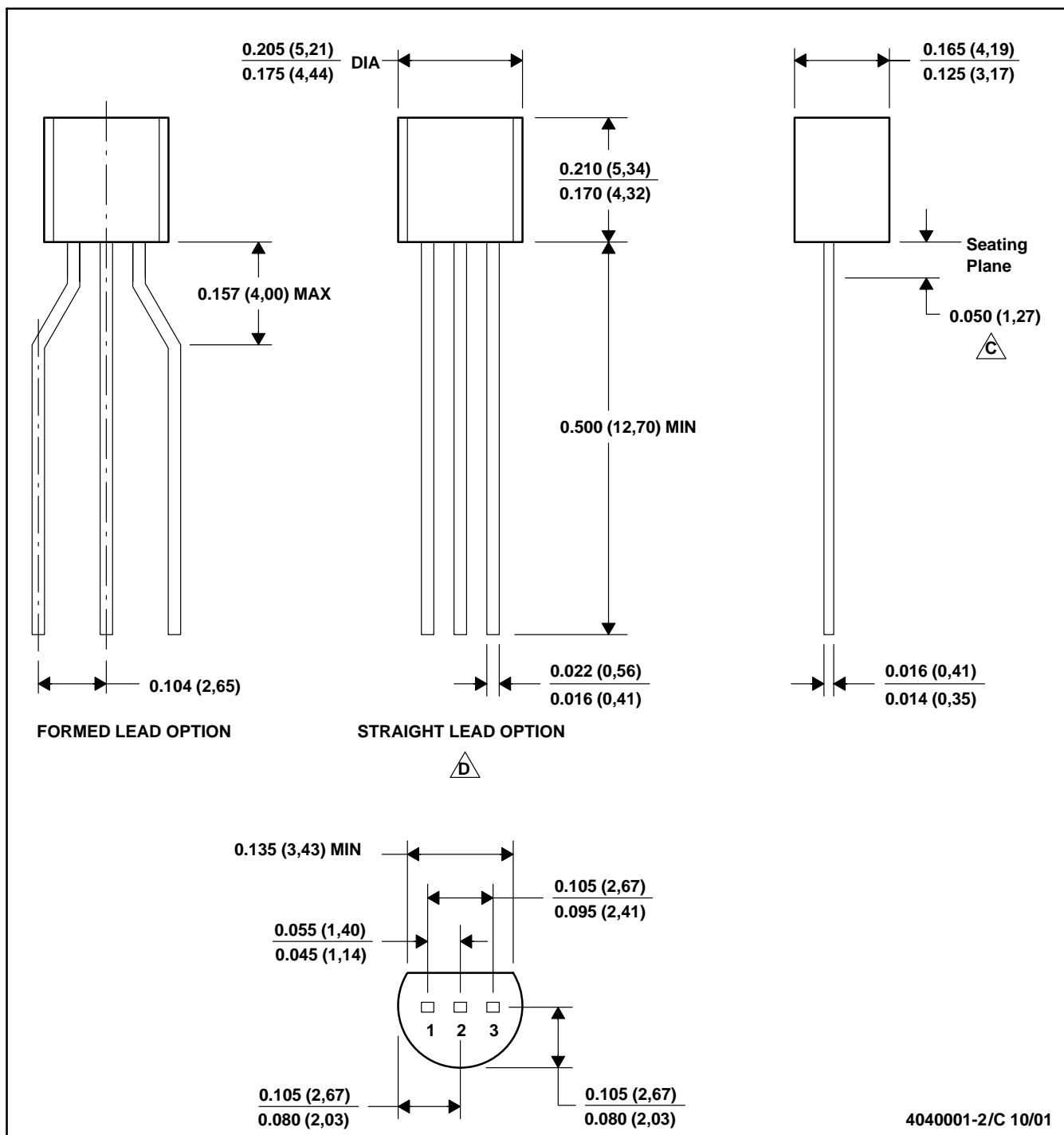
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
  - E. Reference JEDEC MS-012 variation AA.

LP (O-PBCY-W3)

PLASTIC CYLINDRICAL PACKAGE



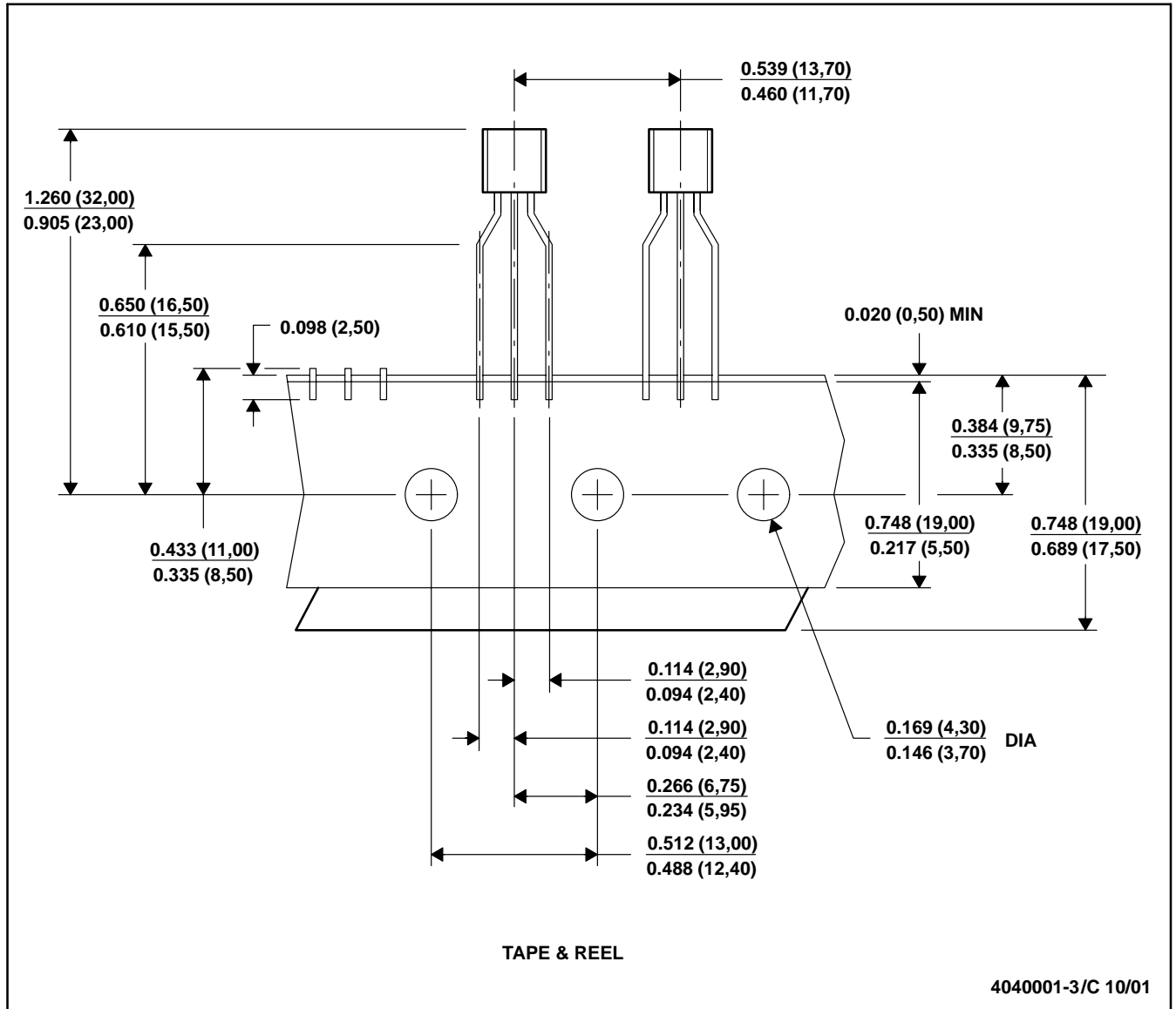
- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Lead dimensions are not controlled within this area  
 D. Falls within JEDEC TO -226 Variation AA (TO-226 replaces TO-92)  
 E. Shipping Method:  
 Straight lead option available in bulk pack only.  
 Formed lead option available in tape & reel or ammo pack.

# MECHANICAL DATA

MSOT002A – OCTOBER 1994 – REVISED NOVEMBER 2001

LP (O-PBCY-W3)

PLASTIC CYLINDRICAL PACKAGE



- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - Tape and Reel information for the Format Lead Option package.

PW (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



4040064/F 01/97

- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.  
 D. Falls within JEDEC MO-153



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