# LM136-2.5-N, LM236-2.5-N, LM336-2.5-NV Reference Diode

**Check for Samples: LM136-2.5-N**

## FEATURES

- **Low Temperature Coefficient**
- **Wide Operating Current of 400 µA to 10 mA**
- **0.2Ω Dynamic Impedance**
- **±1% Initial Tolerance Available**
- **Specified Temperature Stability**
- **Easily Trimmed for Minimum Temperature Drift**
- **Fast Turn-On**

## DESCRIPTION

The LM136-2.5-N/LM236-2.5-N and LM336-2.5-N integrated circuits are precision 2.5V shunt regulator diodes. These monolithic IC voltage references operate as a low-temperature-coefficient 2.5V zener with 0.2Ω dynamic impedance. A third terminal on the LM136-2.5-N allows the reference voltage and temperature coefficient to be trimmed easily.

The LM136-2.5-N series is useful as a precision 2.5V low voltage reference for digital voltmeters, power supplies or op amp circuitry. The 2.5V make it convenient to obtain a stable reference from 5V logic supplies. Further, since the LM136-2.5-N operates as a shunt regulator, it can be used as either a positive or negative voltage reference.

The LM136-2.5-N is rated for operation over −55°C to +125°C while the LM236-2.5-N is rated over a −25°C to +85°C temperature range.

The LM336-2.5-N is rated for operation over a 0°C to +70°C temperature range. See the connection diagrams for available packages.

### Connection Diagram

**TO-92 Plastic Package**

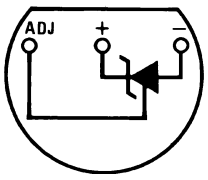



**Figure 1. Bottom View**
**See Package Number LP**

**TO Metal Can Package**

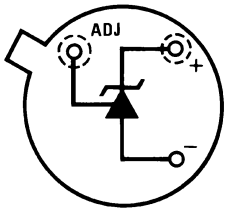



**Figure 2. Bottom View**
**See Package Number NDV**

**SOIC Package**

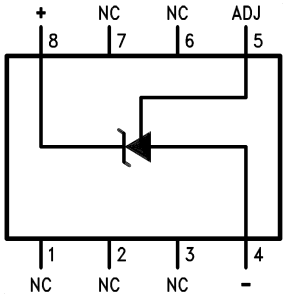



**Figure 3. Top View**
**See Package Number D**

## Typical Applications

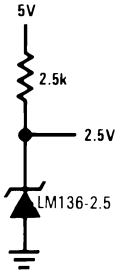
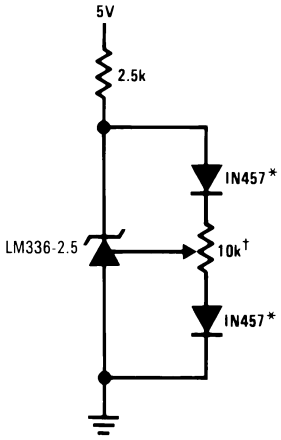



**Figure 4. 2.5V Reference**




†Adjust to 2.490V
*Any silicon signal diode

**Figure 5. 2.5V Reference with Minimum Temperature Coefficient**

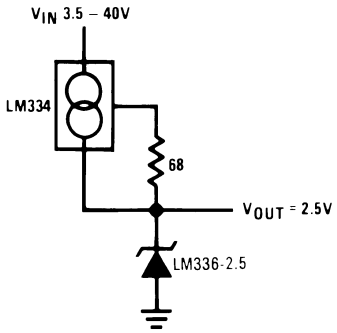



**Figure 6. Wide Input Range Reference**

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## Absolute Maximum Ratings(1)(2)

| | | | |
|---|---|---|---|
| Reverse Current | | | 15 mA |
| Forward Current | | | 10 mA |
| Storage Temperature | | | −60°C to +150°C |
| Operating Temperature Range(3) | | LM136 | −55°C to +150°C |
| | | LM236 | −25°C to +85°C |
| | | LM336 | 0°C to +70°C |
| Soldering Information | TO-92 Package (10 sec.) | | 260°C |
| | TO Package (10 sec.) | | 300°C |
| | SOIC Package | Vapor Phase (60 sec.) | 215°C |
| | | Infrared (15 sec.) | 220°C |

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Electrical specifications do not apply when operating the device beyond its specified operating conditions.
(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
(3) For elevated temperature operation, $T_j$ max is:
LM136 150°C
LM236 125°C
LM336 100°C

| Thermal Resistance | TO-92 | TO | SOIC |
|---|---|---|---|
| $\theta_{ja}$ (Junction to Ambient) | 180°C/W (0.4″ leads) | 440°C/W | 165°C/W |
| | 170°C/W (0.125″ lead) | | |
| $\theta_{ja}$ (Junction to Case) | n/a | 80°C/W | n/a |

## Electrical Characteristics (1)

| Parameter | Conditions | | LM136A-2.5-N/ LM236A-2.5-N LM136-2.5-N/ LM236-2.5-N | | | LM336B-2.5-N LM336-2.5-N | | | Units |
|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | Min | Typ | Max | |
| Reverse Breakdown Voltage | $T_A$=25°C, $I_R$=1 mA | LM136, LM236, LM336 | 2.440 | 2.490 | 2.540 | 2.390 | 2.490 | 2.590 | V |
| | | LM136A, LM236A, LM336B | 2.465 | 2.490 | 2.515 | 2.440 | 2.490 | 2.540 | V |
| Reverse Breakdown Change With Current | $T_A$=25°C, 400 µA≤$I_R$≤10 mA | | | 2.6 | 6 | | 2.6 | 10 | mV |
| Reverse Dynamic Impedance | $T_A$=25°C, $I_R$=1 mA, f = 100 Hz | | | 0.2 | 0.6 | | 0.2 | 1 | Ω |
| Temperature Stability(2) | $V_R$ Adjusted to 2.490V $I_R$=1 mAFigure 15 | 0°C≤$T_A$≤70°C (LM336) | | | | | 1.8 | 6 | mV |
| | | −25°C≤$T_A$≤+85°C (LM236H, LM236Z) | | 3.5 | 9 | | | | mV |
| | | −25°C ≤ $T_A$ ≤ +85°C (LM236M) | | 7.5 | 18 | | | | mV |
| | | −55°C≤$T_A$≤+125°C (LM136) | | 12 | 18 | | | | mV |
| Reverse Breakdown Change With Current | 400 µA≤$I_R$≤10 mA | | | 3 | 10 | | 3 | 12 | mV |
| Reverse Dynamic Impedance | $I_R$=1 mA | | | 0.4 | 1 | | 0.4 | 1.4 | Ω |
| Long Term Stability | $T_A$=25°C ±0.1°C, $I_R$=1 mA, t = 1000 hrs | | | 20 | | | 20 | | ppm |

(1) Unless otherwise specified, the LM136-2.5-N is specified from −55°C ≤ $T_A$ ≤ +125°C, the LM236-2.5-N from −25°C ≤ $T_A$ ≤ +85°C and the LM336-2.5-N from 0°C ≤ $T_A$ ≤ +70°C.

(2) Temperature stability for the LM336 and LM236 family is specified by design. Design limits are ensured (but not 100% production tested) over the indicated temperature and supply voltage ranges. These limits are not used to calculate outgoing quality levels. Stability is defined as the maximum change in $V_{ref}$ from 25°C to $T_A$ (min) or $T_A$ (max).

## Typical Performance Characteristics

Reverse Voltage Change

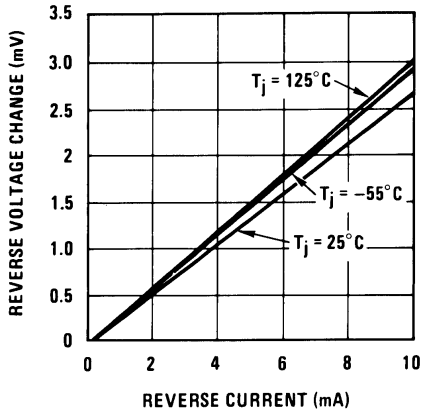



Figure 7.

Zener Noise Voltage

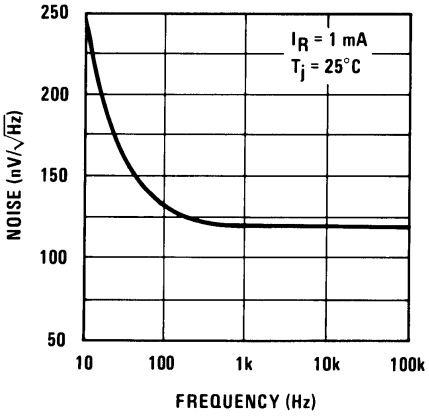



Figure 8.

Dynamic Impedance

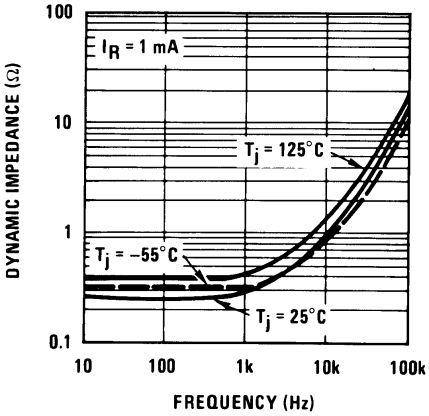



Figure 9.

Response Time

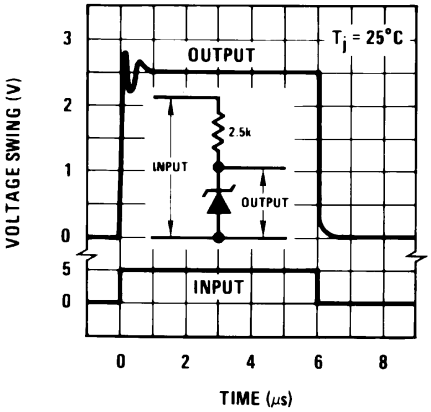



Figure 10.

Reverse Characteristics

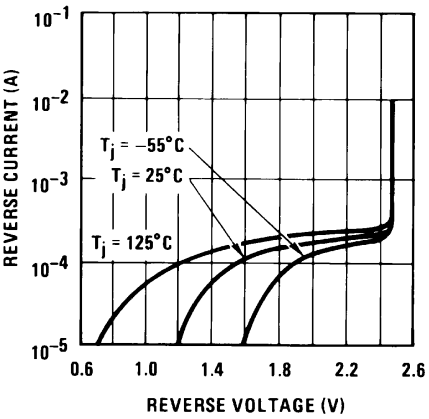



Figure 11.

Forward Characteristics

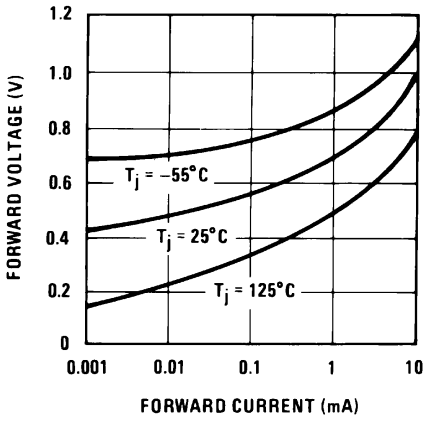



Figure 12.

## Typical Performance Characteristics (continued)

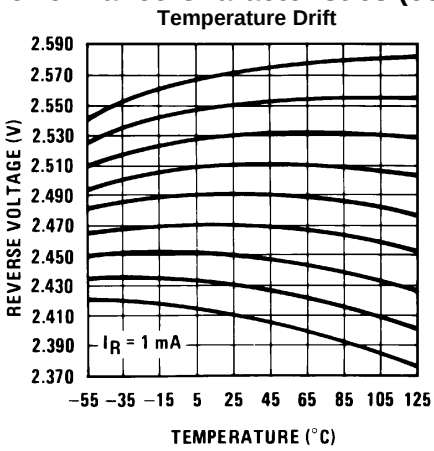



**Figure 13.**

## APPLICATION HINTS

The LM136 series voltage references are much easier to use than ordinary zener diodes. Their low impedance and wide operating current range simplify biasing in almost any circuit. Further, either the breakdown voltage or the temperature coefficient can be adjusted to optimize circuit performance.

Figure 14 shows an LM136 with a 10k potentiometer for adjusting the reverse breakdown voltage. With the addition of R1 the breakdown voltage can be adjusted without affecting the temperature coefficient of the device. The adjustment range is usually sufficient to adjust for both the initial device tolerance and inaccuracies in buffer circuitry.

If minimum temperature coefficient is desired, two diodes can be added in series with the adjustment potentiometer as shown in Figure 15. When the device is adjusted to 2.490V the temperature coefficient is minimized. Almost any silicon signal diode can be used for this purpose such as a 1N914, 1N4148 or a 1N457. For proper temperature compensation the diodes should be in the same thermal environment as the LM136. It is usually sufficient to mount the diodes near the LM136 on the printed circuit board. The absolute resistance of R1 is not critical and any value from 2k to 20k will work.

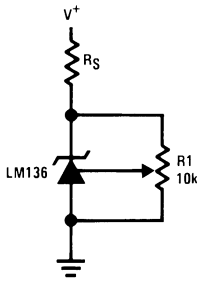



**Figure 14. LM136 With Pot for Adjustment of Breakdown Voltage (Trim Range = ±120 mV typical)**

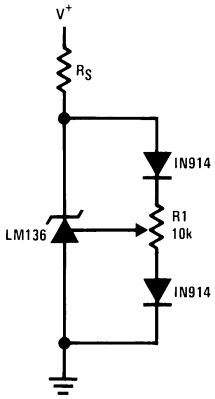
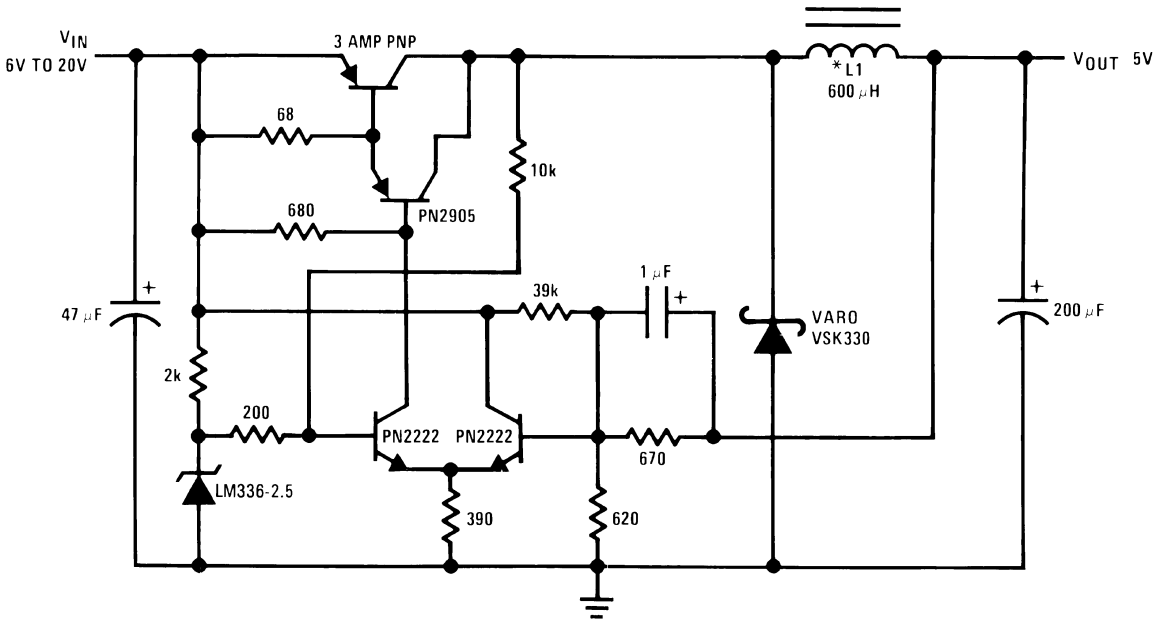



**Figure 15. Temperature Coefficient Adjustment (Trim Range = ±70 mV typical)**




*L1 60 turns #16 wire on Arnold Core A-254168-2
†Efficiency ≈ 80%

**Figure 16. Low Cost 2 Amp Switching Regulator†**

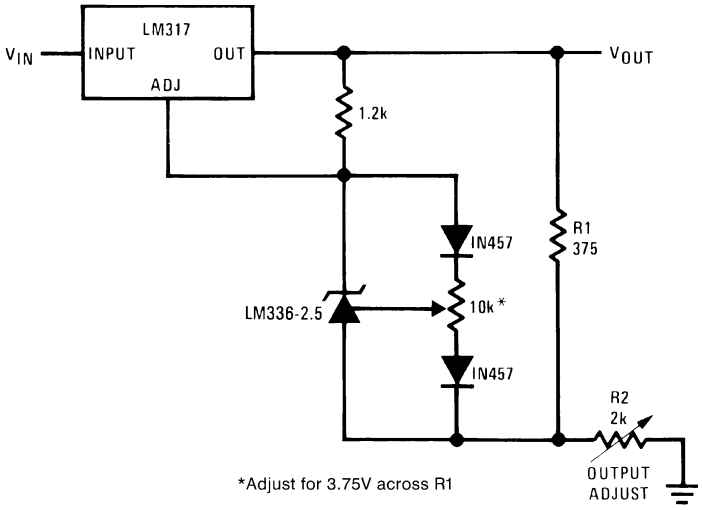



**Figure 17. Precision Power Regulator with Low Temperature Coefficient**

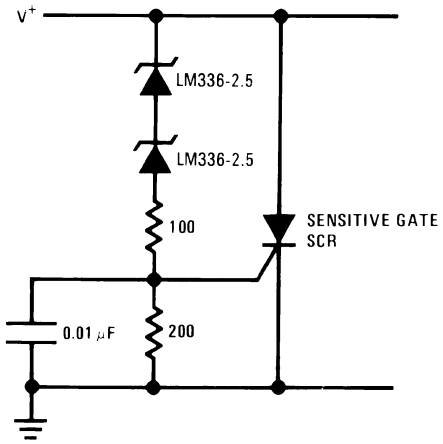
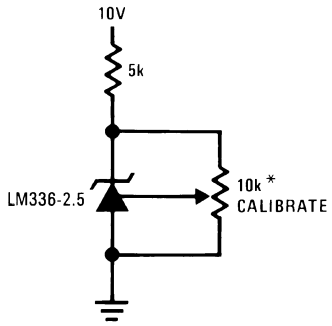



**Figure 18. 5V Crowbar**




*Does not affect temperature coefficient

**Figure 19. Trimmed 2.5V Reference with Temperature Coefficient Independent of Breakdown Voltage**

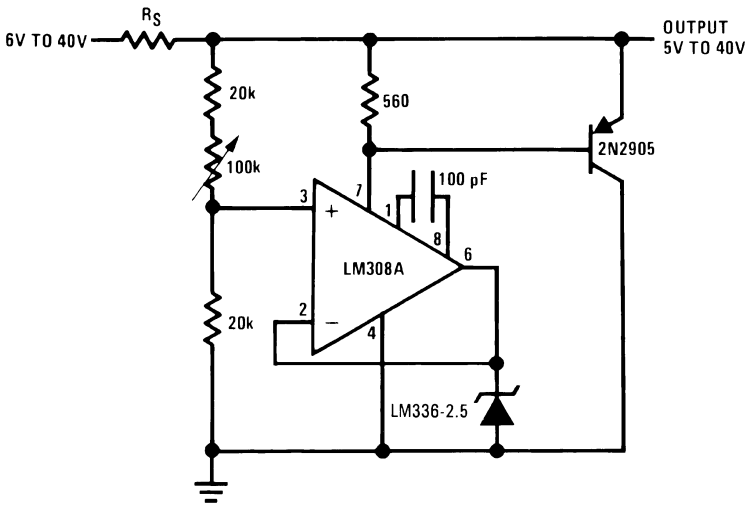



**Figure 20. Adjustable Shunt Regulator**

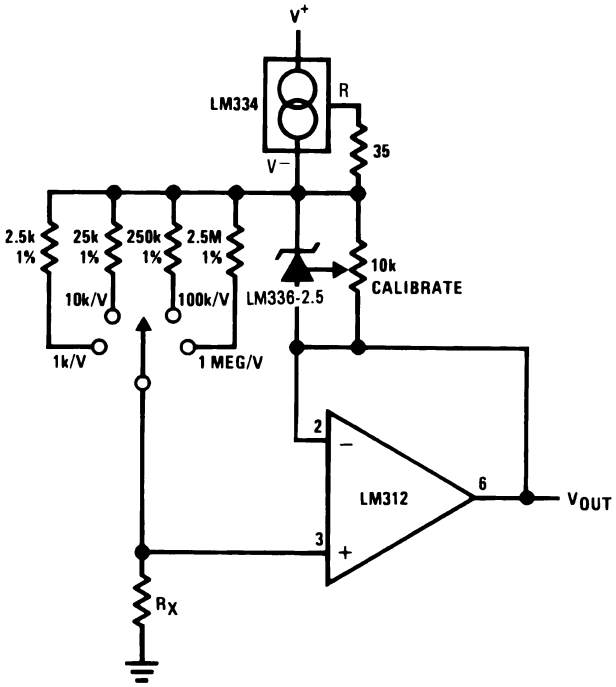



**Figure 21. Linear Ohmmeter**

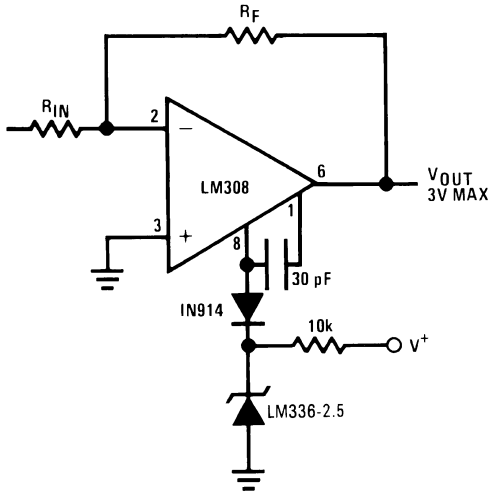



**Figure 22. Op Amp with Output Clamped**

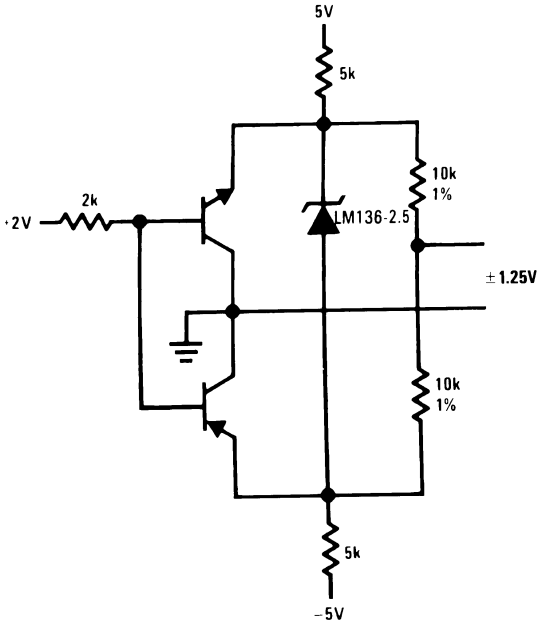



**Figure 23. Bipolar Output Reference**

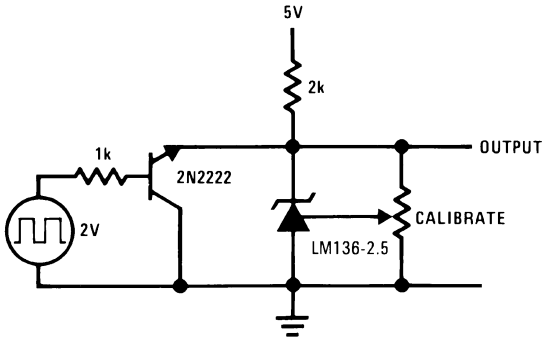



**Figure 24. 2.5V Square Wave Calibrator**

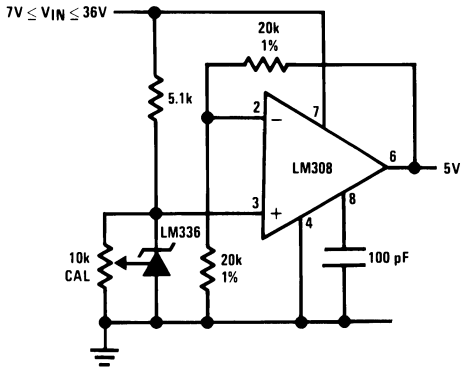



**Figure 25. 5V Buffered Reference**

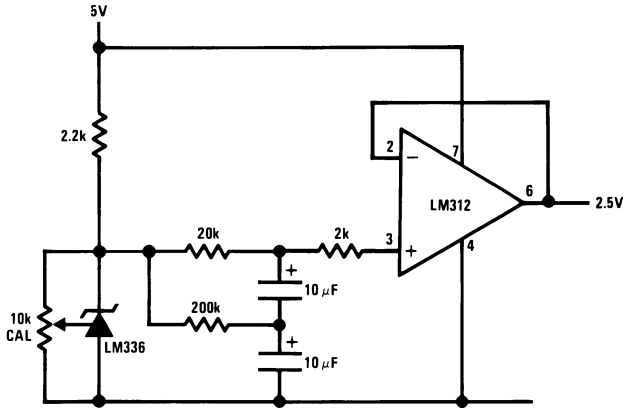
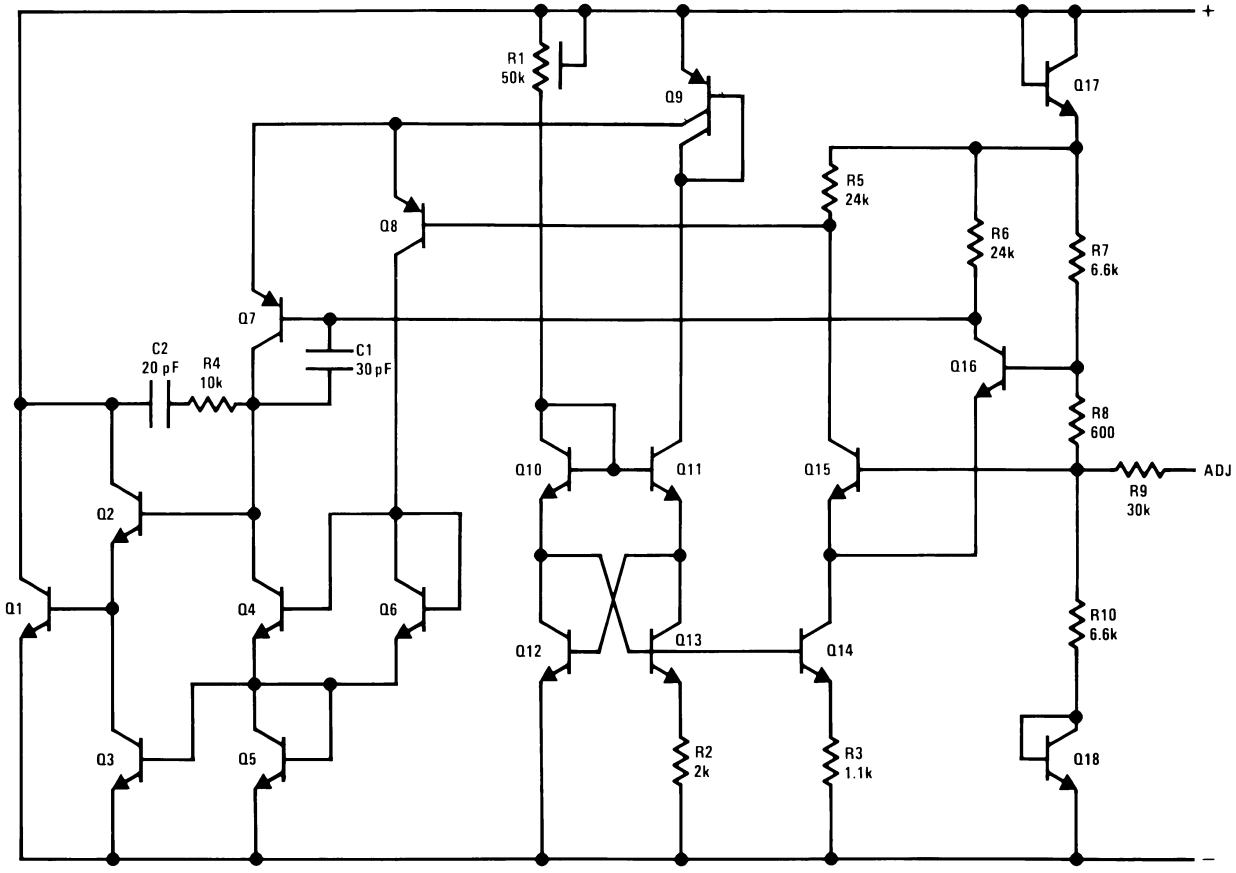



**Figure 26. Low Noise Buffered Reference**

## Schematic Diagram



## REVISION HISTORY

| Changes from Revision E (April 2013) to Revision F | Page |
|---|---|
| • Changed layout of National Data Sheet to TI format | 11 |

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LM136AH-2.5 | ACTIVE | TO | NDV | 3 | 1000 | Non-RoHS & Green | Call TI | Level-1-NA-UNLIM | -40 to 125 | ( LM136AH2.5, LM136AH2.5) | Samples |
| LM136AH-2.5/NOPB | ACTIVE | TO | NDV | 3 | 1000 | RoHS & Green | Call TI | Level-1-NA-UNLIM | -40 to 125 | ( LM136AH2.5, LM136AH2.5) | Samples |
| LM136H-2.5 | ACTIVE | TO | NDV | 3 | 1000 | Non-RoHS & Green | Call TI | Level-1-NA-UNLIM | -55 to 125 | ( LM136H2.5, LM136H2.5) | Samples |
| LM136H-2.5/NOPB | ACTIVE | TO | NDV | 3 | 1000 | RoHS & Green | Call TI | Level-1-NA-UNLIM | -55 to 125 | ( LM136H2.5, LM136H2.5) | Samples |
| LM236H-2.5 | ACTIVE | TO | NDV | 3 | 1000 | Non-RoHS & Green | Call TI | Level-1-NA-UNLIM | -25 to 85 | ( LM236H2.5, LM236H2.5) | Samples |
| LM236H-2.5/NOPB | ACTIVE | TO | NDV | 3 | 1000 | RoHS & Green | Call TI | Level-1-NA-UNLIM | -25 to 85 | ( LM236H2.5, LM236H2.5) | Samples |
| LM336BM-2.5/NOPB | ACTIVE | SOIC | D | 8 | 95 | RoHS & Green | SN | Level-1-260C-UNLIM | 0 to 70 | LM336 BM2.5 | Samples |
| LM336BMX-2.5/NOPB | ACTIVE | SOIC | D | 8 | 2500 | RoHS & Green | SN | Level-1-260C-UNLIM | 0 to 70 | LM336 BM2.5 | Samples |
| LM336BZ-2.5/LFT7 | ACTIVE | TO-92 | LP | 3 | 2000 | RoHS & Green | Call TI | N / A for Pkg Type | | LM336 BZ2.5 | Samples |
| LM336BZ-2.5/NOPB | ACTIVE | TO-92 | LP | 3 | 1800 | RoHS & Green | Call TI | N / A for Pkg Type | 0 to 70 | LM336 BZ2.5 | Samples |
| LM336M-2.5/NOPB | ACTIVE | SOIC | D | 8 | 95 | RoHS & Green | SN | Level-1-260C-UNLIM | 0 to 70 | LM336 M2.5 | Samples |
| LM336MX-2.5/NOPB | ACTIVE | SOIC | D | 8 | 2500 | RoHS & Green | SN | Level-1-260C-UNLIM | 0 to 70 | LM336 M2.5 | Samples |
| LM336Z-2.5/LFT1 | ACTIVE | TO-92 | LP | 3 | 2000 | RoHS & Green | SN | N / A for Pkg Type | | LM336 Z2.5 | Samples |
| LM336Z-2.5/LFT3 | ACTIVE | TO-92 | LP | 3 | 2000 | RoHS & Green | SN | N / A for Pkg Type | | LM336 Z2.5 | Samples |
| LM336Z-2.5/LFT7 | ACTIVE | TO-92 | LP | 3 | 2000 | RoHS & Green | SN | N / A for Pkg Type | | LM336 Z2.5 | Samples |
| LM336Z-2.5/NOPB | ACTIVE | TO-92 | LP | 3 | 1800 | RoHS & Green | Call TI | N / A for Pkg Type | 0 to 70 | LM336 Z2.5 | Samples |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.
**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

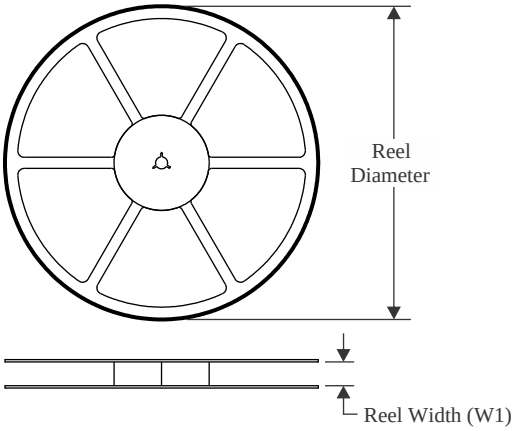
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

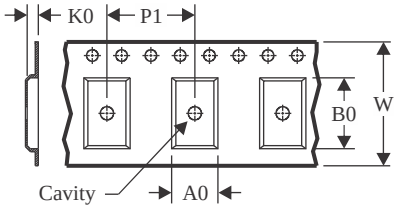
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

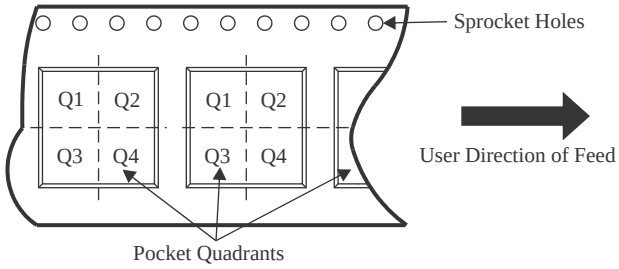



**TAPE DIMENSIONS**




| | |
|---|---|
| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

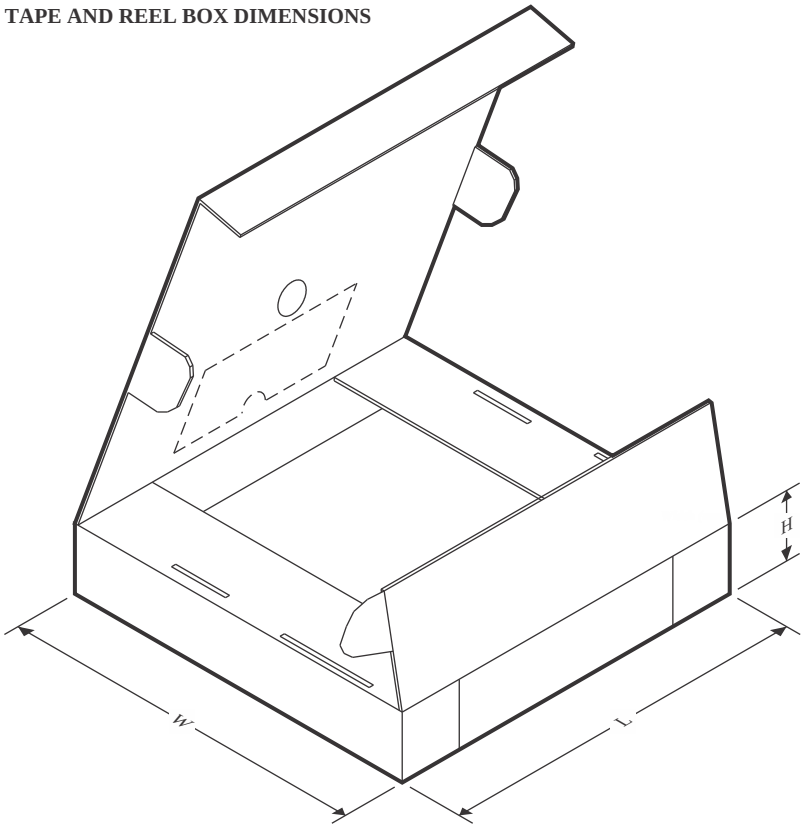
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LM336BMX-2.5/NOPB | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |
| LM336MX-2.5/NOPB | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |

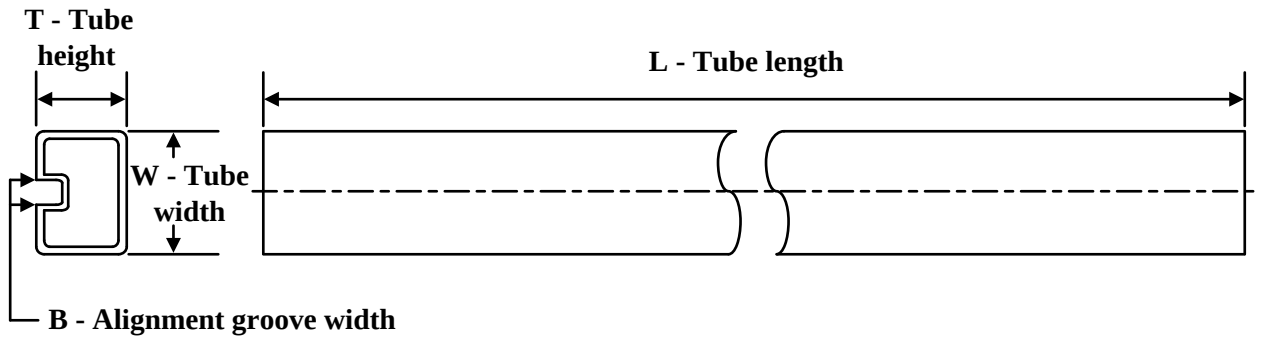
TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| LM336BMX-2.5/NOPB | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| LM336MX-2.5/NOPB | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |

## TUBE




*All dimensions are nominal

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (µm) | B (mm) |
|---|---|---|---|---|---|---|---|---|
| LM336BM-2.5/NOPB | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM336M-2.5/NOPB | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |

# GENERIC PACKAGE VIEW

## LP 3 TO-92 - 5.34 mm max height

TRANSISTOR OUTLINE

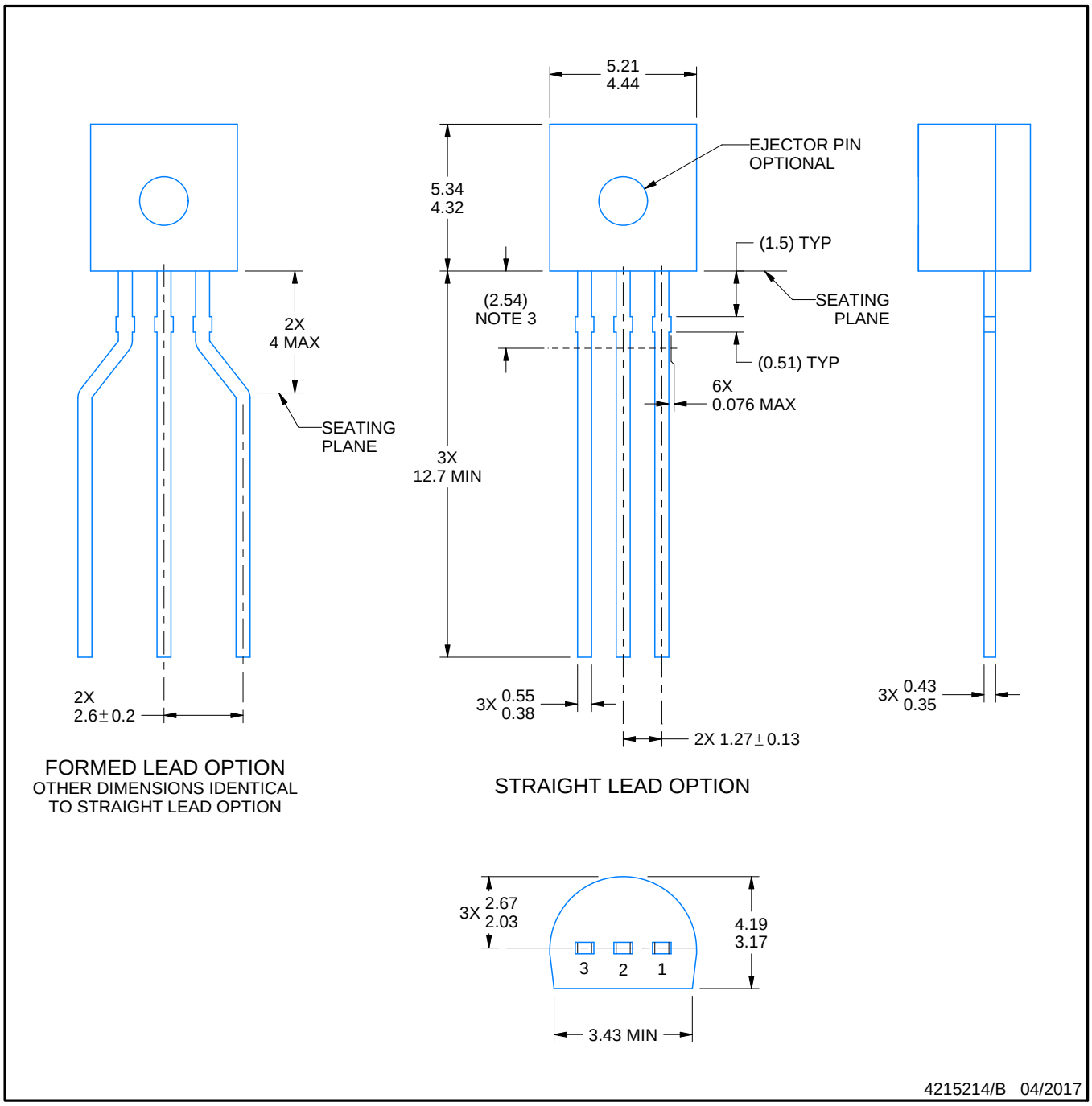
Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

# LP0003A

## PACKAGE OUTLINE

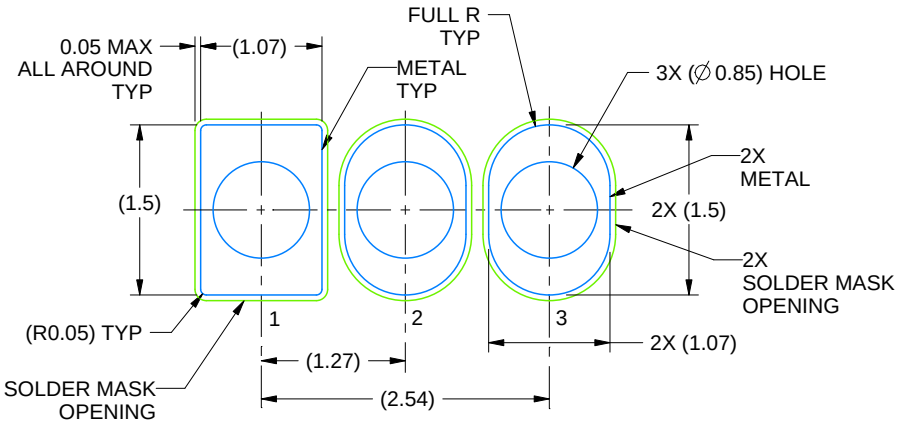
### TO-92 - 5.34 mm max height

TO-92

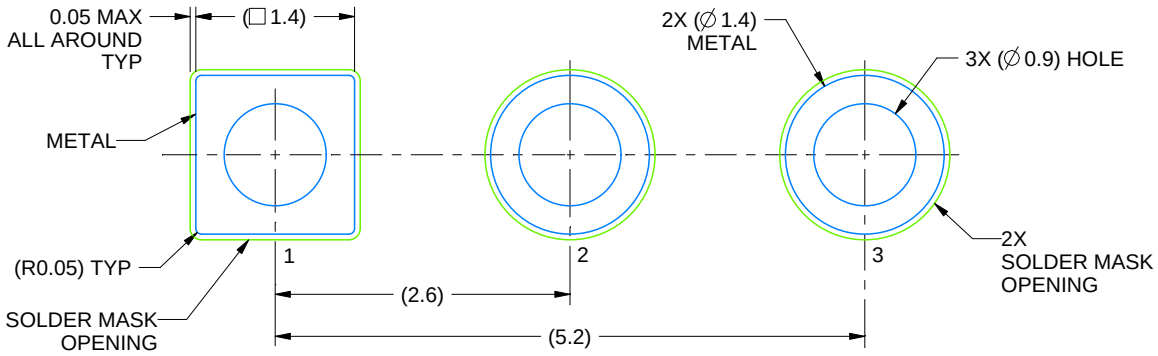



NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Lead dimensions are not controlled within this area.
4. Reference JEDEC TO-226, variation AA.
5. Shipping method:
   a. Straight lead option available in bulk pack only.
   b. Formed lead option available in tape and reel or ammo pack.
   c. Specific products can be offered in limited combinations of shipping medium and lead options.
   d. Consult product folder for more information on available options.




LAND PATTERN EXAMPLE
STRAIGHT LEAD OPTION
NON-SOLDER MASK DEFINED
SCALE:15X



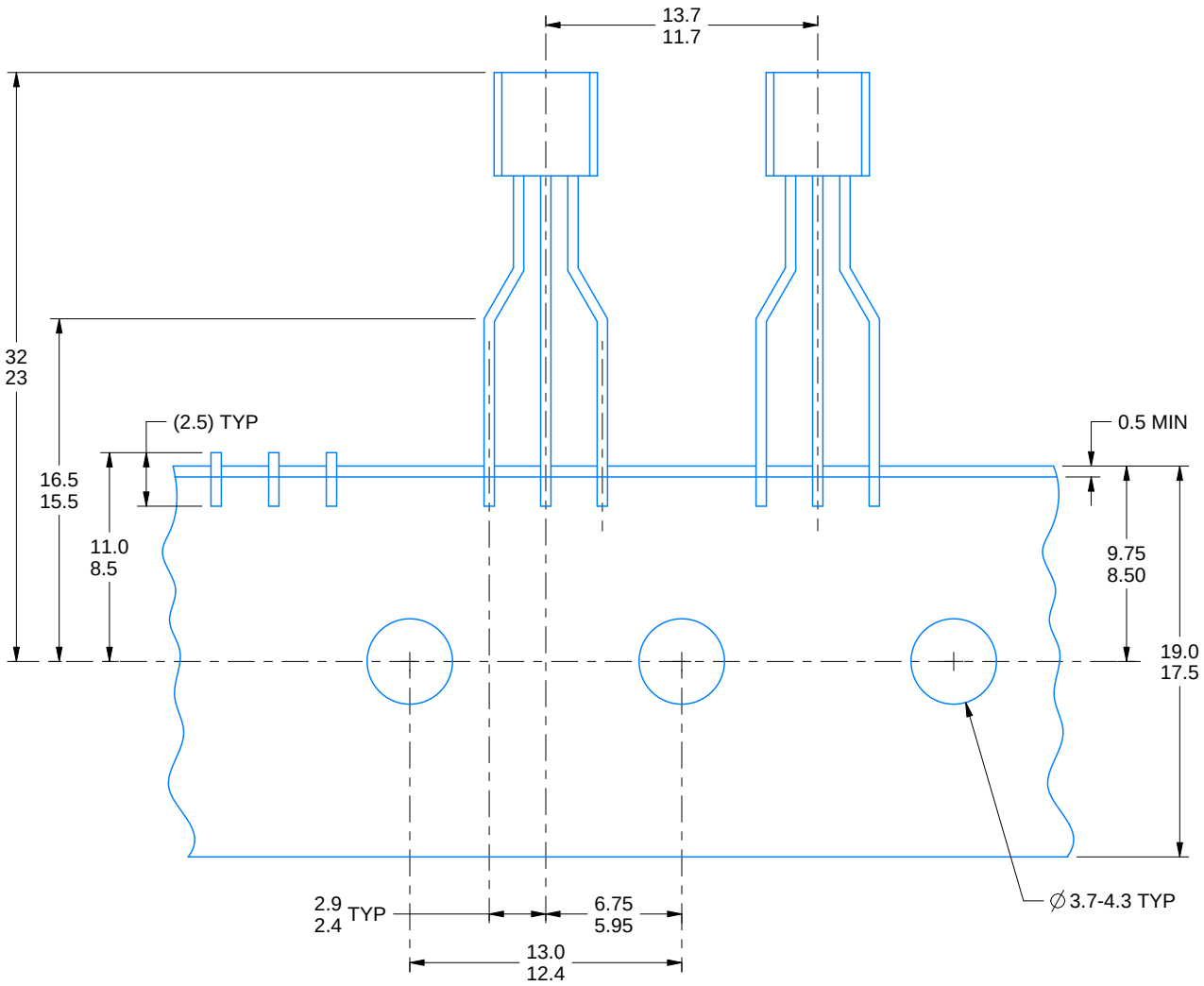

LAND PATTERN EXAMPLE
FORMED LEAD OPTION
NON-SOLDER MASK DEFINED
SCALE:15X

4215214/B 04/2017

# LP0003A

## TO-92 - 5.34 mm max height

TO-92




FOR FORMED LEAD OPTION PACKAGE

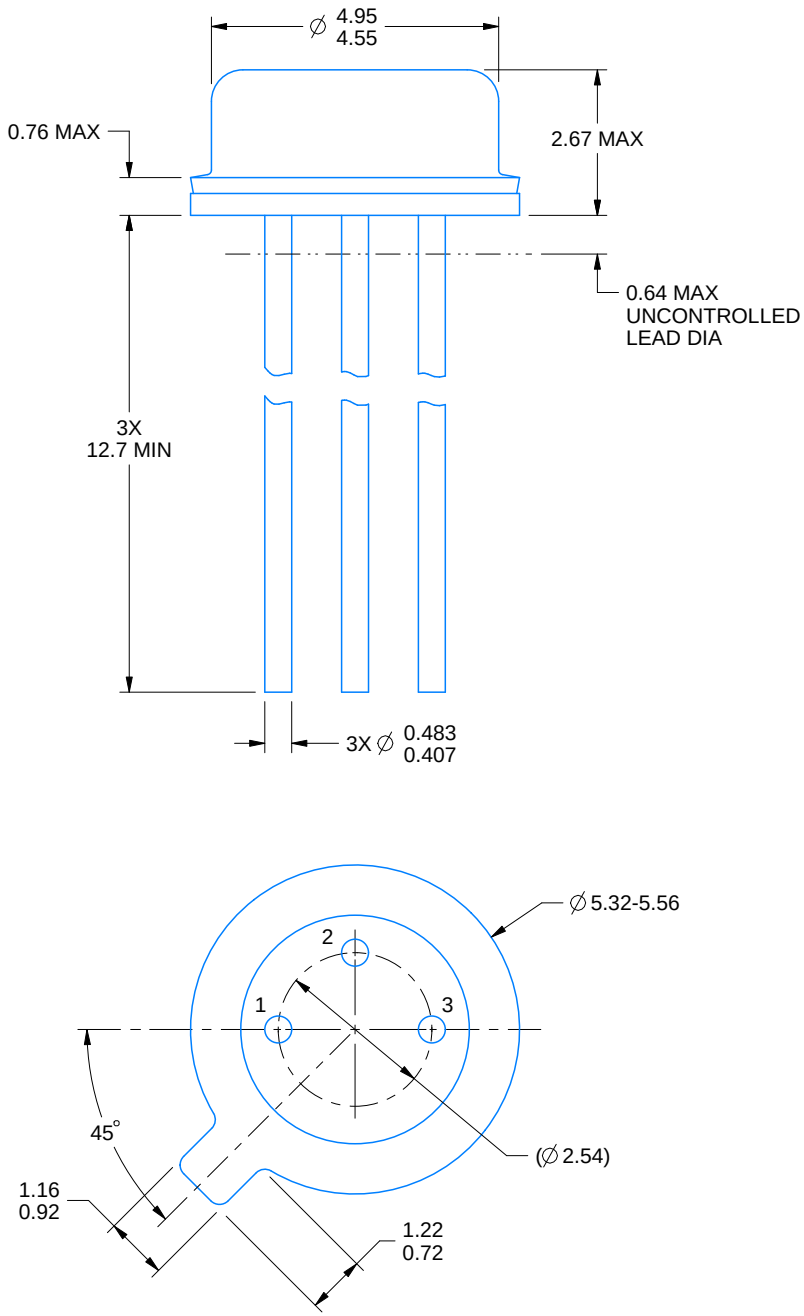
4215214/B 04/2017

# PACKAGE OUTLINE

## NDV0003H

## TO-CAN - 2.67 mm max height

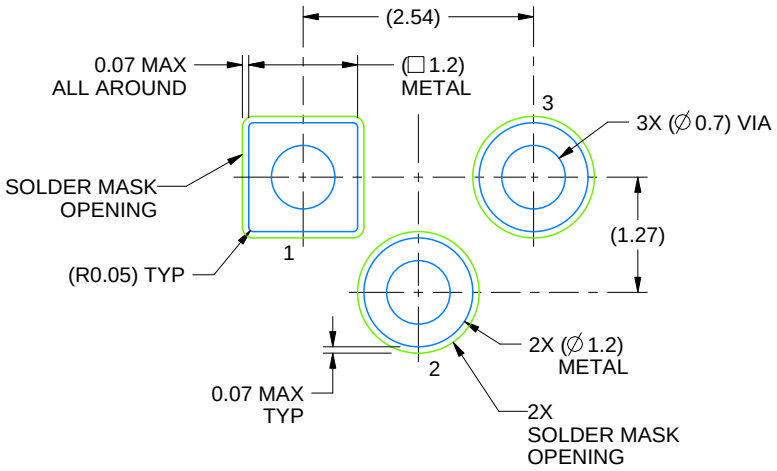
TO-46




4219876/A 01/2017

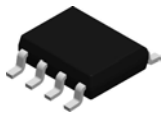
NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration TO-46.




LAND PATTERN EXAMPLE
NON-SOLDER MASK DEFINED
SCALE:12X

4219876/A 01/2017

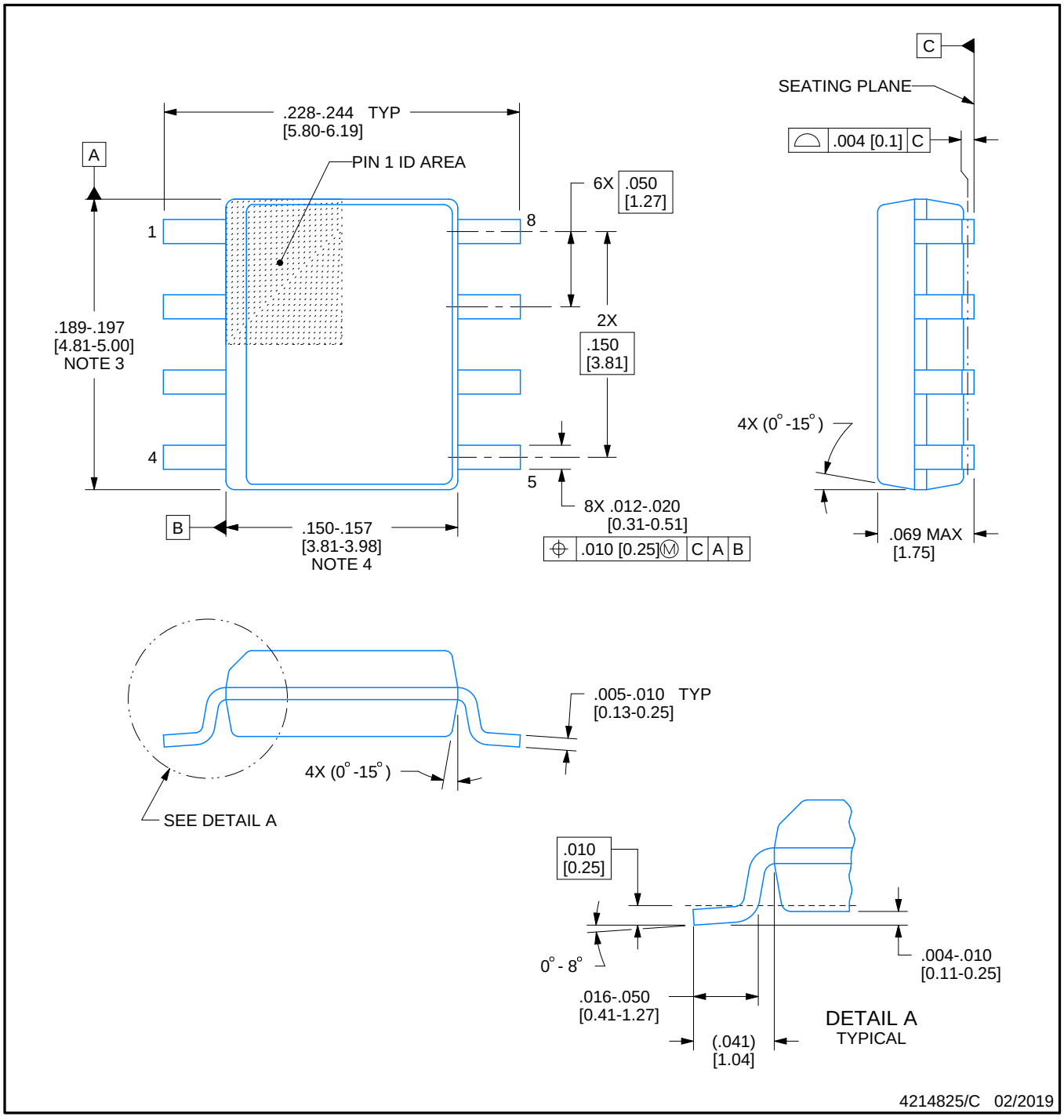


# PACKAGE OUTLINE

## D0008A

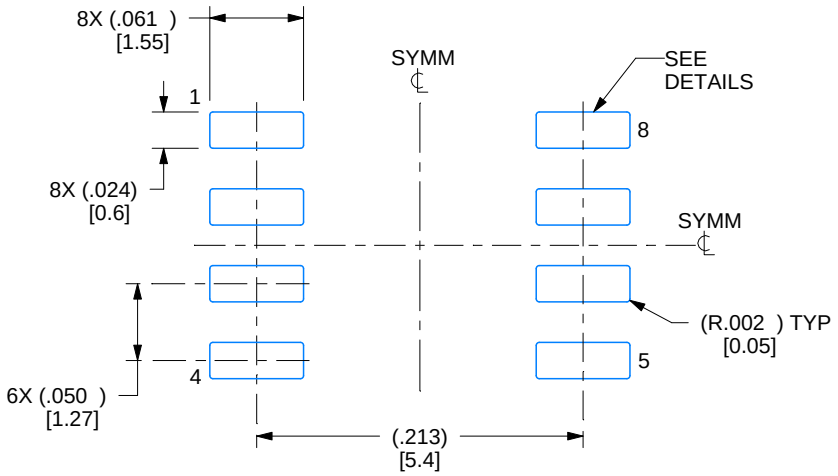
## SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

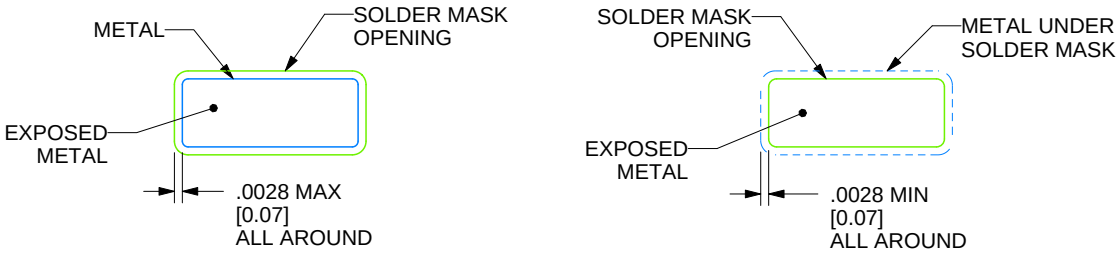



NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X




SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

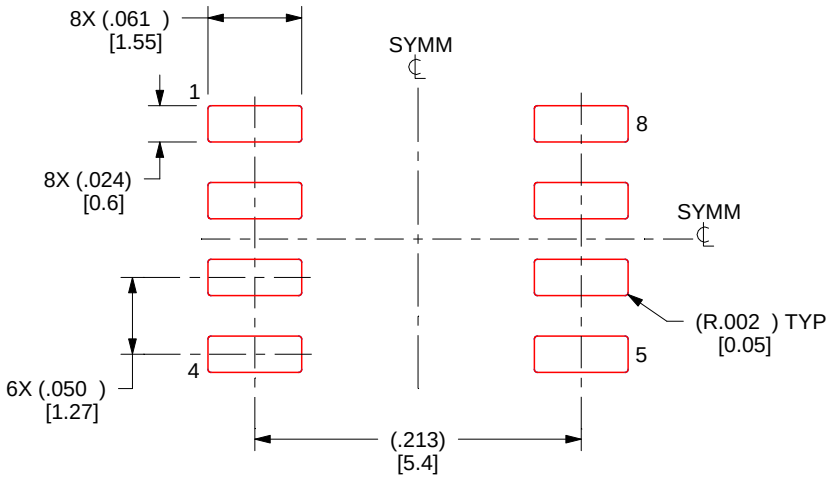
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

## D0008A

## SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT




SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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