# LM833-N Dual Audio Operational Amplifier

**Check for Samples: LM833-N**

## FEATURES

- **Wide Dynamic Range: >140dB**
- **Low Input Noise Voltage: 4.5nV/√Hz**
- **High Slew Rate: 7 V/µs (typ); 5V/µs (Min)**
- **High Gain Bandwidth: 15MHz (typ); 10MHz (Min)**
- **Wide Power Bandwidth: 120KHz**
- **Low Distortion: 0.002%**
- **Low Offset Voltage: 0.3mV**
- **Large Phase Margin: 60°**
- **Available in 8 Pin VSSOP Package**

## DESCRIPTION

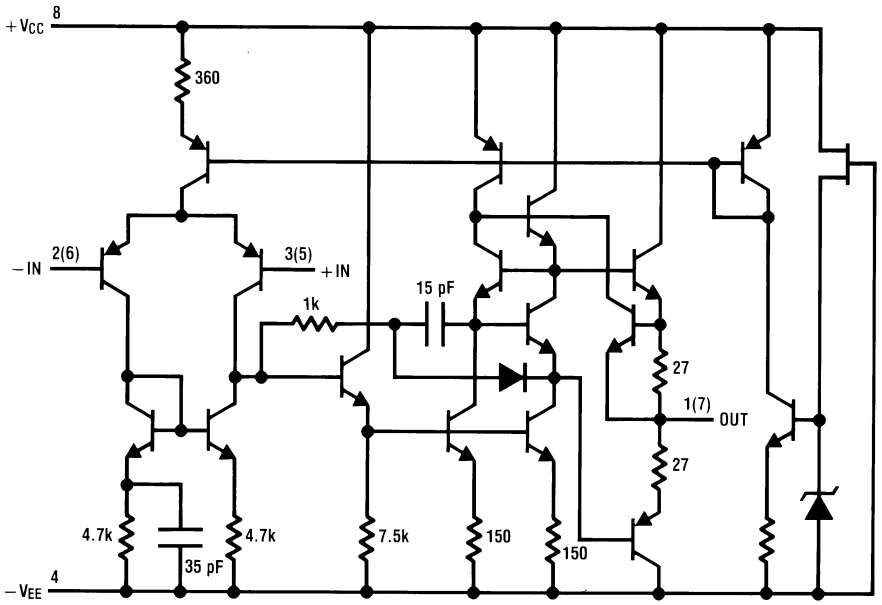
The LM833-N is a dual general purpose operational amplifier designed with particular emphasis on performance in audio systems.

This dual amplifier IC utilizes new circuit and processing techniques to deliver low noise, high speed and wide bandwidth without increasing external components or decreasing stability. The LM833-N is internally compensated for all closed loop gains and is therefore optimized for all preamp and high level stages in PCM and HiFi systems.

The LM833-N is pin-for-pin compatible with industry standard dual operational amplifiers.

### Schematic Diagram

(1/2 LM833-N)

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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of the Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

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## Connection Diagram

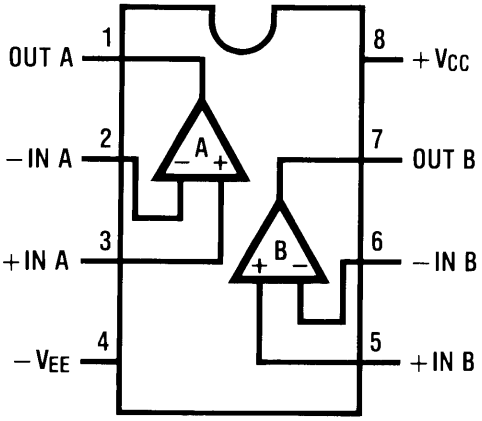


**Figure 1. See Package Number D0008A, P0008E or DGK0008A**

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)

| | | | |
|---|---|---|---|
| Supply Voltage $V_{CC}$–$V_{EE}$ | | | 36V |
| Differential Input Voltage(3) $V_I$ | | | ±30V |
| Input Voltage Range(3) $V_{IC}$ | | | ±15V |
| Power Dissipation(4) $P_D$ | | | 500 mW |
| Operating Temperature Range $T_{OPR}$ | | | −40 ~ 85°C |
| Storage Temperature Range $T_{STG}$ | | | −60 ~ 150°C |
| Soldering Information | PDIP Package | Soldering (10 seconds) | 260°C |
| | Small Outline Package (SOIC and VSSOP) | Vapor Phase (60 seconds) | 215°C |
| | | Infrared (15 seconds) | 220°C |
| ESD tolerance (5) | | | 1600V |

(1) *Absolute Maximum Ratings* indicate limits beyond which damage to the device may occur. *Operating Ratings* indicate conditions for which the device is functional, but do not ensure specific performance limits. *Electrical Characteristics* state DC and AC electrical specifications under particular test conditions which ensure specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not ensured for parameters where no limit is given, however, the typical value is a good indication of device performance.
(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
(3) If supply voltage is less than ±15V, it is equal to supply voltage.
(4) This is the permissible value at $T_A \leq 85°C$.
(5) Human body model, 1.5 kΩ in series with 100 pF.


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## DC ELECTRICAL CHARACTERISTICS(1)(2)

($T_A$ = 25°C, $V_S$ = ±15V)

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | $R_S$ = 10Ω | | 0.3 | 5 | mV |
| $I_{OS}$ | Input Offset Current | | | 10 | 200 | nA |
| $I_B$ | Input Bias Current | | | 500 | 1000 | nA |
| $A_V$ | Voltage Gain | $R_L$ = 2 kΩ, $V_O$ = ±10V | 90 | 110 | | dB |
| $V_{OM}$ | Output Voltage Swing | $R_L$ = 10 kΩ | ±12 | ±13.5 | | V |
| | | $R_L$ = 2 kΩ | ±12 | ±13.4 | | V |
| $V_{CM}$ | Input Common-Mode Range | | ±12 | ±14.0 | | V |
| CMRR | Common-Mode Rejection Ratio | $V_{IN}$ = ±12V | 80 | 100 | | dB |
| PSRR | Power Supply Rejection Ratio | $V_S$ = 15 ~ 5V, −15 ~ −5V | 80 | 100 | | dB |
| $I_Q$ | Supply Current | $V_O$ = 0V, Both Amps | | 5 | 8 | mA |

(1) *Absolute Maximum Ratings* indicate limits beyond which damage to the device may occur. *Operating Ratings* indicate conditions for which the device is functional, but do not ensure specific performance limits. *Electrical Characteristics* state DC and AC electrical specifications under particular test conditions which ensure specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not ensured for parameters where no limit is given, however, the typical value is a good indication of device performance.
(2) All voltages are measured with respect to the ground pin, unless otherwise specified.

## AC ELECTRICAL CHARACTERISTICS

($T_A$ = 25°C, $V_S$ = ±15V, $R_L$ = 2 kΩ)

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| SR | Slew Rate | $R_L$ = 2 kΩ | 5 | 7 | | V/µs |
| GBW | Gain Bandwidth Product | f = 100 kHz | 10 | 15 | | MHz |
| $V_{NI}$ | Equivalent Input Noise Voltage (LM833AM, LM833AMX) | RIAA, $R_S$ = 2.2 kΩ(1) | | | 1.4 | µV |

(1) RIAA Noise Voltage Measurement Circuit

## DESIGN ELECTRICAL CHARACTERISTICS

($T_A$ = 25°C, $V_S$ = ±15V)
The following parameters are not tested or ensured.

| Symbol | Parameter | Conditions | Typ | Units |
|---|---|---|---|---|
| $\Delta V_{OS}/\Delta T$ | Average Temperature Coefficient of Input Offset Voltage | | 2 | µV/°C |
| THD | Distortion | $R_L$ = 2 kΩ, f = 20~20 kHz<br>$V_{OUT}$ = 3 Vrms, $A_V$ = 1 | 0.002 | % |
| $e_n$ | Input Referred Noise Voltage | $R_S$ = 100Ω, f = 1 kHz | 4.5 | nV / $\sqrt{Hz}$ |
| $i_n$ | Input Referred Noise Current | f = 1 kHz | 0.7 | pA / $\sqrt{Hz}$ |
| PBW | Power Bandwidth | $V_O$ = 27 $V_{pp}$, $R_L$ = 2 kΩ, THD ≤ 1% | 120 | kHz |
| $f_U$ | Unity Gain Frequency | Open Loop | 9 | MHz |
| $\varphi_M$ | Phase Margin | Open Loop | 60 | deg |
| | Input Referred Cross Talk | f = 20~20 kHz | −120 | dB |

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## TYPICAL PERFORMANCE CHARACTERISTICS

**Maximum Power Dissipation vs Ambient Temperature**

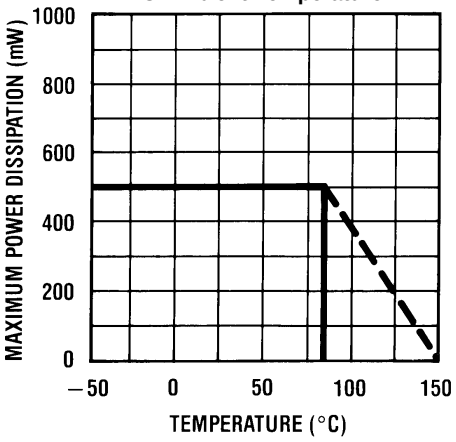


**Figure 2.**

**Input Bias Current vs Ambient Temperature**

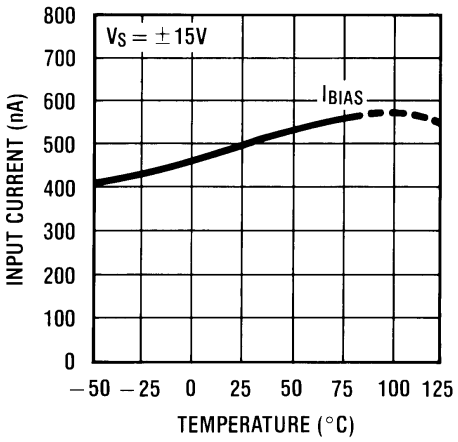


**Figure 3.**

**Input Bias Current vs Supply Voltage**

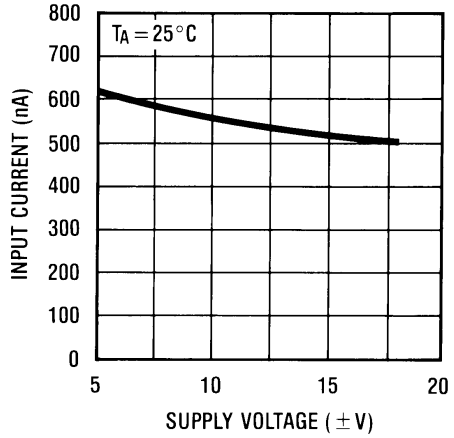


**Figure 4.**

**Supply Current vs Supply Voltage**

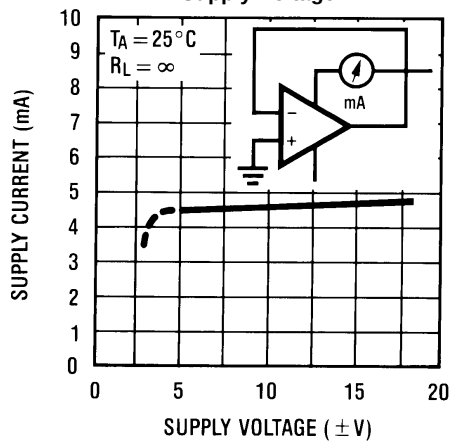


**Figure 5.**

**DC Voltage Gain vs Ambient Temperature**

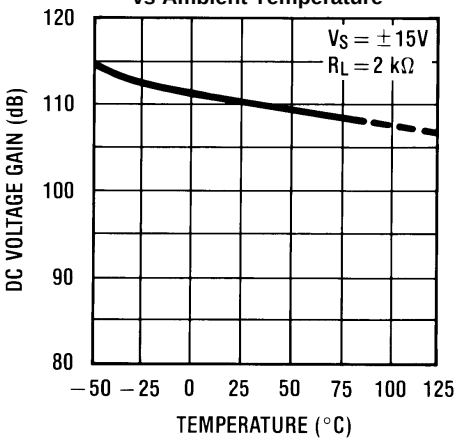


**Figure 6.**

**DC Voltage Gain vs Supply Voltage**

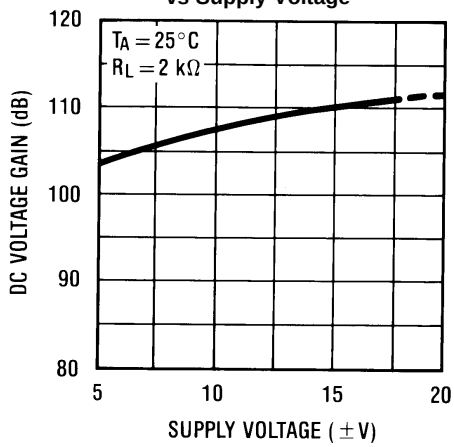


**Figure 7.**


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## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

**Voltage Gain & Phase vs Frequency**

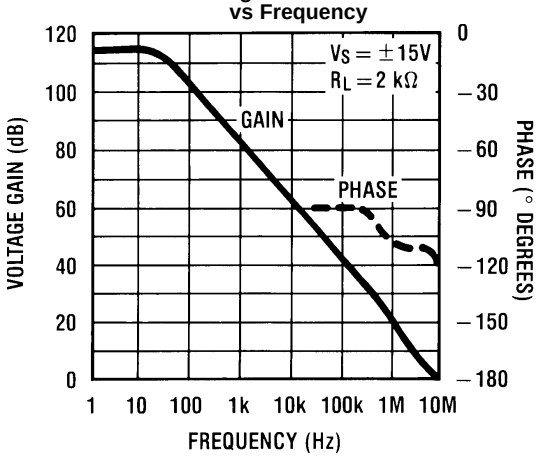


**Figure 8.**

**Gain Bandwidth Product vs Ambient Temperature**

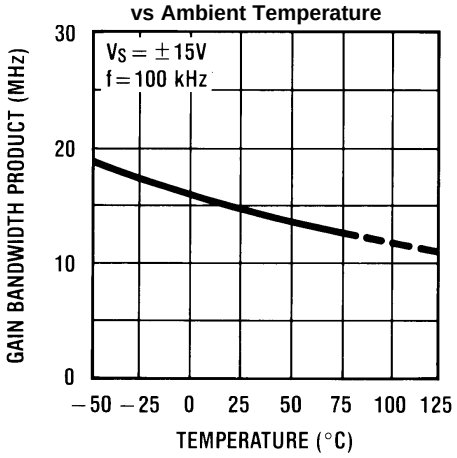


**Figure 9.**

**Gain Bandwidth vs Supply Voltage**

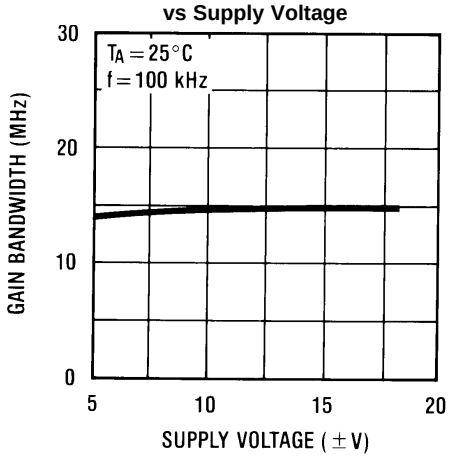


**Figure 10.**

**Slew Rate vs Ambient Temperature**

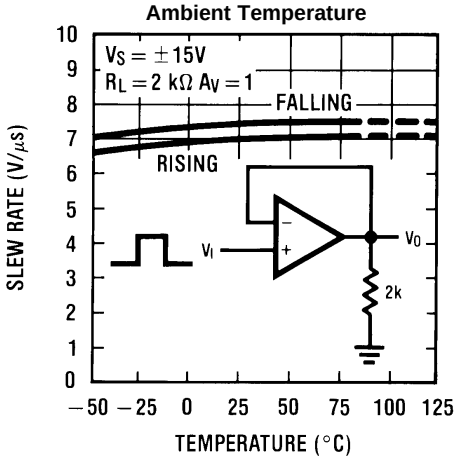


**Figure 11.**

**Slew Rate vs Supply Voltage**

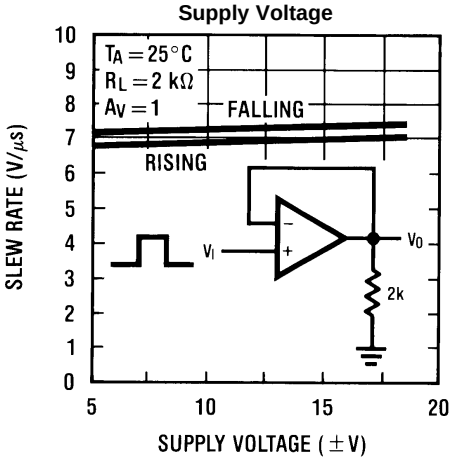


**Figure 12.**

**Power Bandwidth**

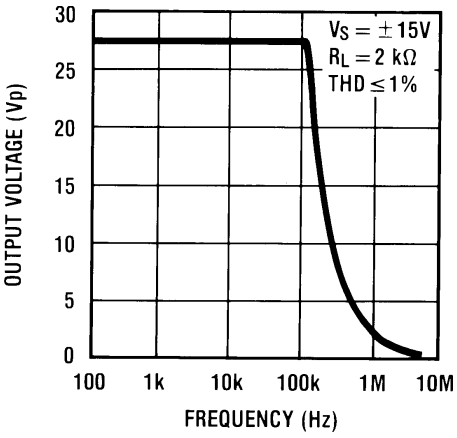


**Figure 13.**

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## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

**CMR vs Frequency**

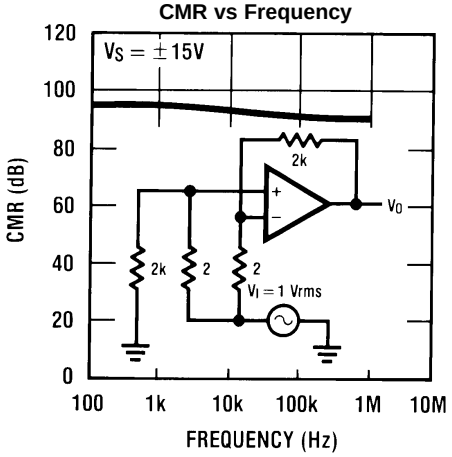


**Figure 14.**

**Distortion vs Frequency**

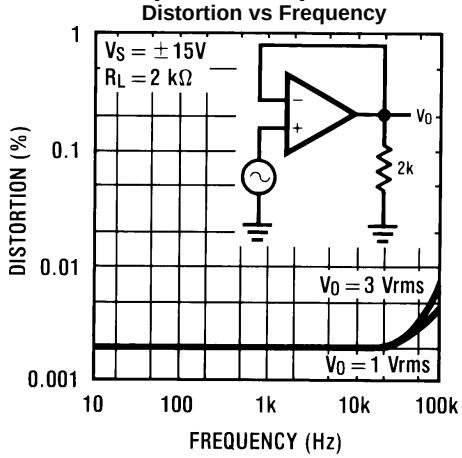


**Figure 15.**

**PSRR vs Frequency**

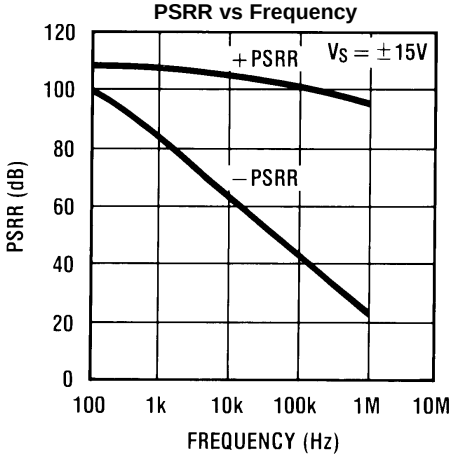


**Figure 16.**

**Maximum Output Voltage vs Supply Voltage**

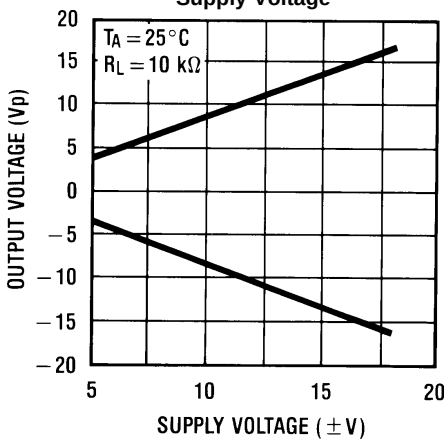


**Figure 17.**

**Maximum Output Voltage vs Ambient Temperature**

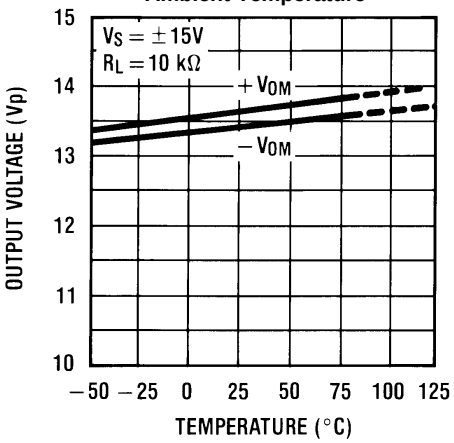


**Figure 18.**

**Spot Noise Voltage vs Frequency**

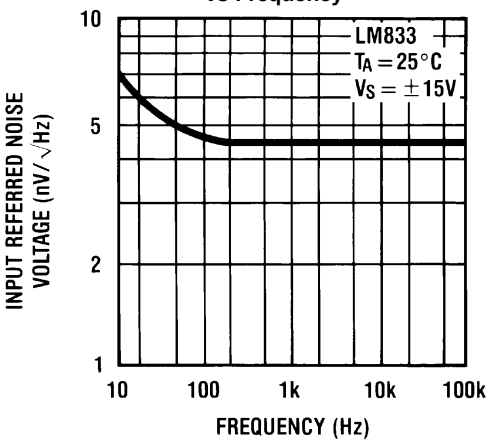


**Figure 19.**


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## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

**Spot Noise Current vs Frequency**

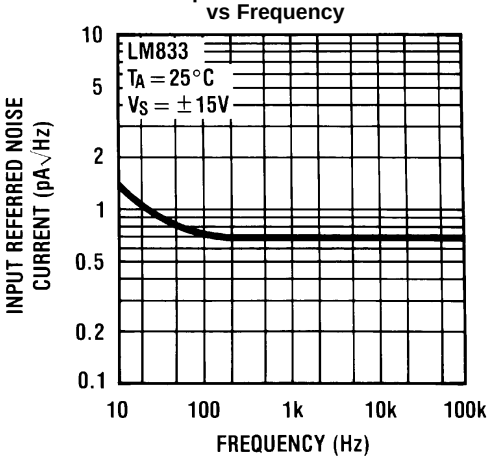


Figure 20.

**Input Referred Noise Voltage vs Source Resistance**

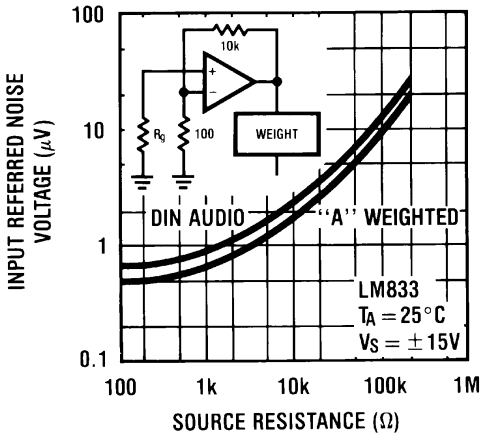


Figure 21.

**Noninverting Amp**

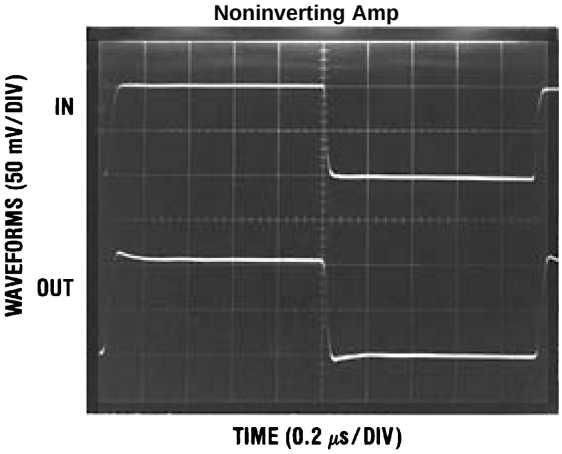


Figure 22.

**Noninverting Amp**

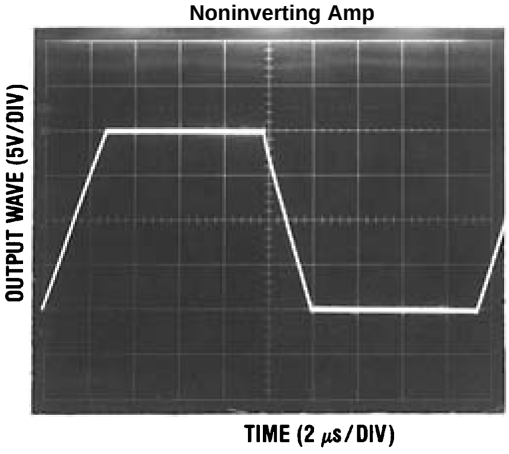


Figure 23.

**Inverting Amp**

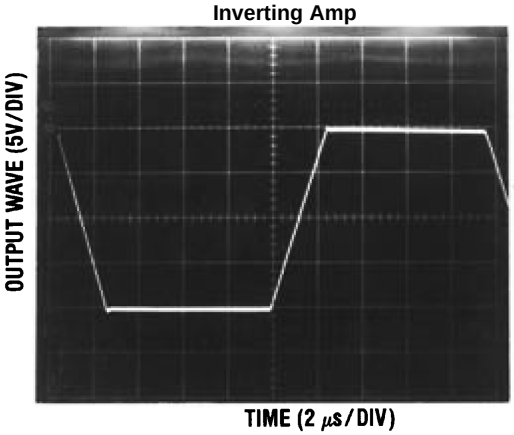


Figure 24.

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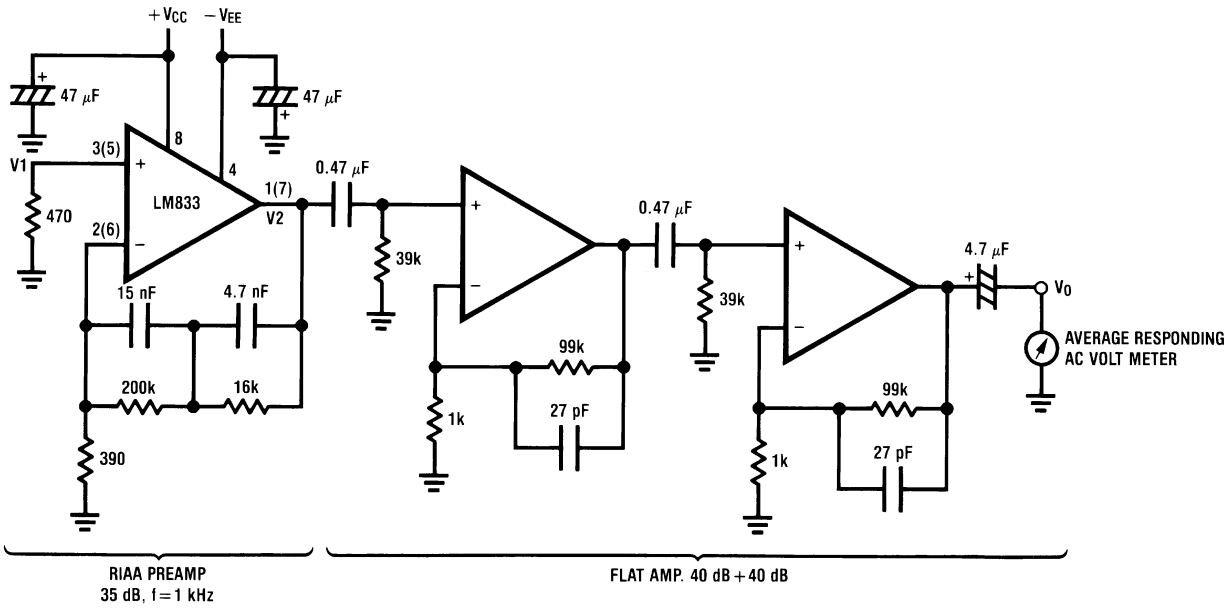
## APPLICATION HINTS

The LM833-N is a high speed op amp with excellent phase margin and stability. Capacitive loads up to 50 pF will cause little change in the phase characteristics of the amplifiers and are therefore allowable.

Capacitive loads greater than 50 pF must be isolated from the output. The most straightforward way to do this is to put a resistor in series with the output. This resistor will also prevent excess power dissipation if the output is accidentally shorted.

### Noise Measurement Circuit




Complete shielding is required to prevent induced pick up from external sources. Always check with oscilloscope for power line noise.

**Figure 25. Total Gain: 115 dB @f = 1 kHz**
**Input Referred Noise Voltage: $e_n$ = V0/560,000 (V)**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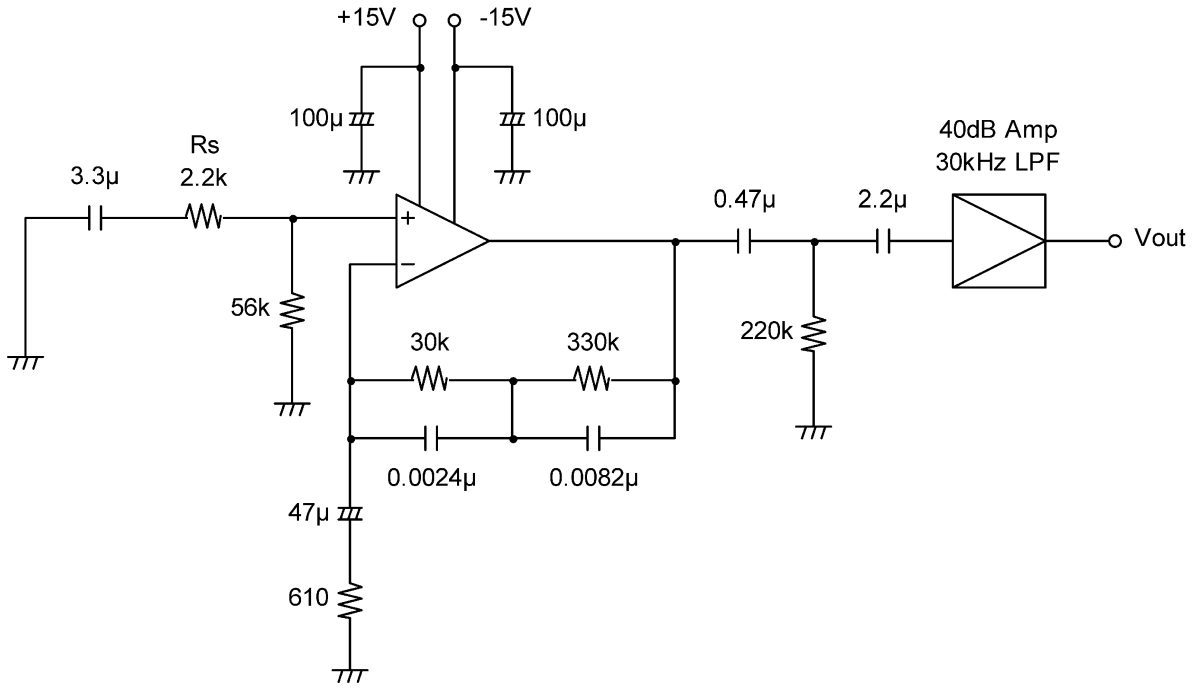
## RIAA Noise Voltage Measurement Circuit




**RIAA Preamp Voltage Gain, RIAA Deviation vs Frequency**

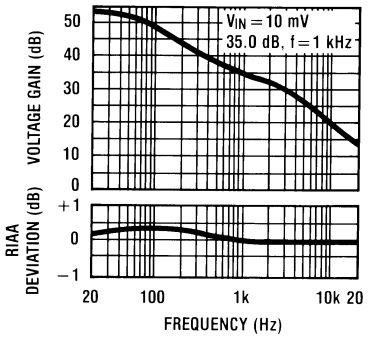



**Figure 26.**

**Flat Amp Voltage Gain vs Frequency**

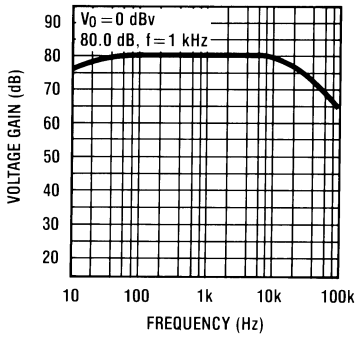
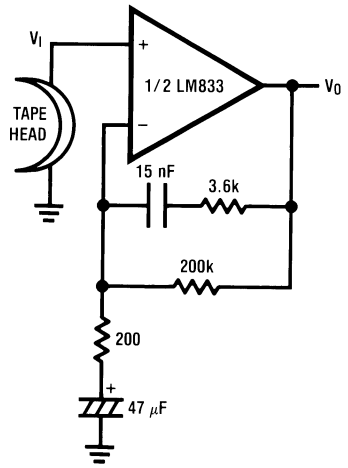



**Figure 27.**

## Typical Applications




$A_V$ = 34.5
F = 1 kHz
$E_n$ = 0.38 μV
A Weighted

**Figure 28. NAB Preamp**

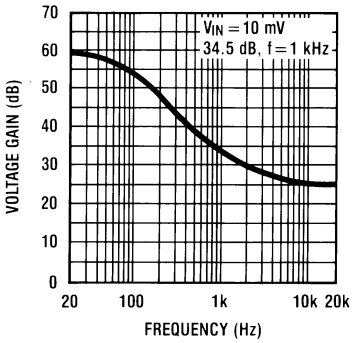
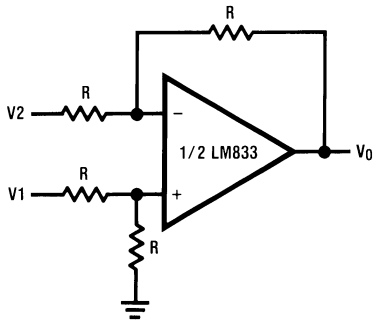



**Figure 29. NAB Preamp Voltage Gain vs Frequency**




$V_O$ = V1–V2

**Figure 30. Balanced to Single Ended Converter**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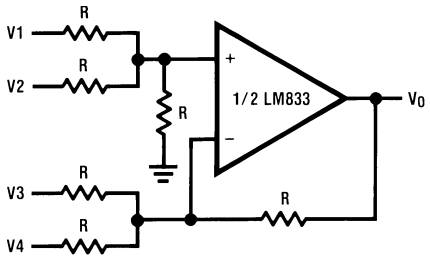
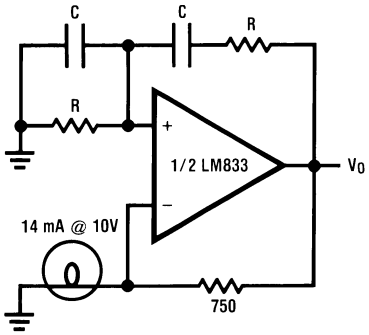


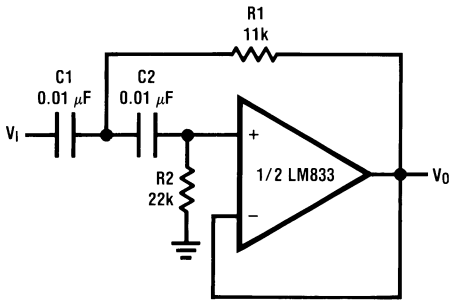

$V_O = V1 + V2 - V3 - V4$

**Figure 31. Adder/Subtracter**




$$f_o = \frac{1}{2\pi RC}$$

**Figure 32. Sine Wave Oscillator**



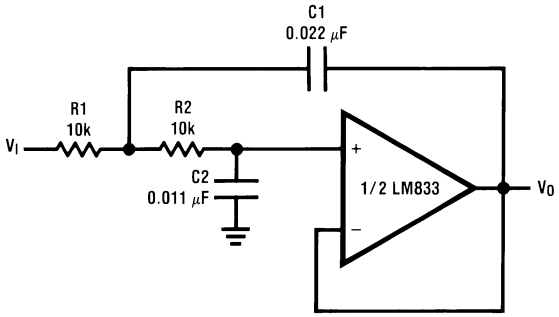

if C1 = C2 = C

$$R1 = \frac{\sqrt{2}}{2\omega_o C}$$

$$R2 = 2 \bullet R1$$

Illustration is $f_0$ = 1 kHz

**Figure 33. Second Order High Pass Filter (Butterworth)**



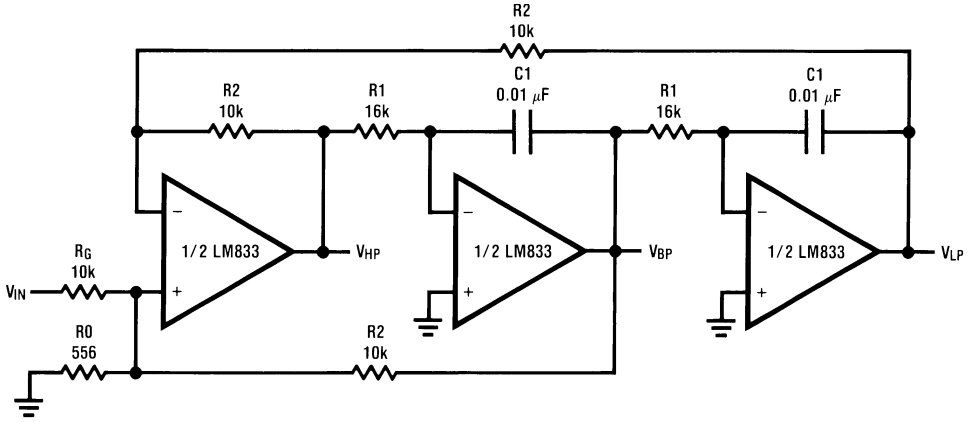

if R1 = R2 = R

$$C1 = \frac{\sqrt{2}}{\omega_o R}$$

$$C2 = \frac{C1}{2}$$

Illustration is $f_0$ = 1 kHz

**Figure 34. Second Order Low Pass Filter (Butterworth)**




$$f_0 = \frac{1}{2\pi C1R1}, Q = \frac{1}{2}\left(1 + \frac{R2}{R0} + \frac{R2}{RG}\right), A_{BP} = QA_{LP} = QA_{LH} = \frac{R2}{RG}$$

Illustration is $f_0$ = 1 kHz, Q = 10, $A_{BP}$ = 1

**Figure 35. State Variable Filter**

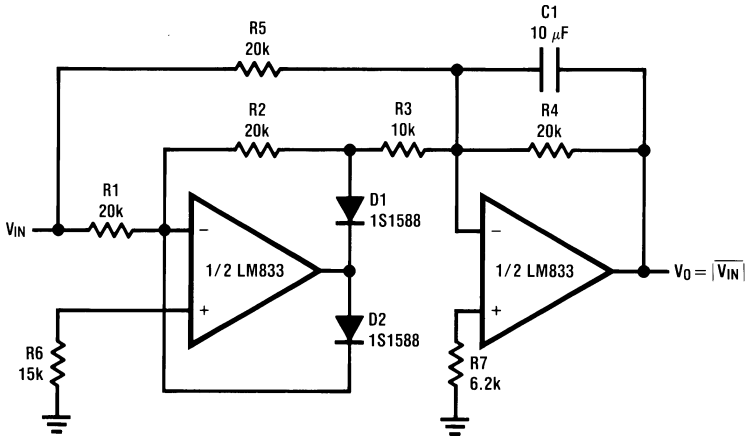



**Figure 36. AC/DC Converter**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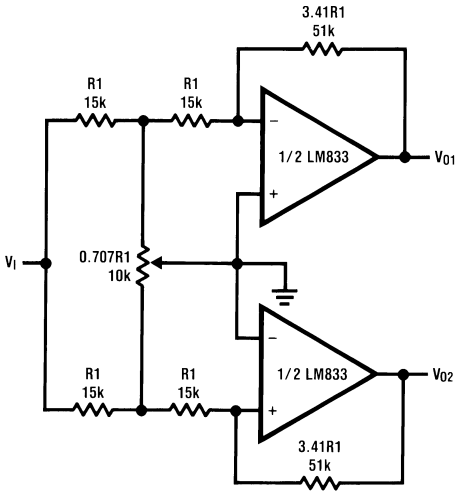



**Figure 37. 2 Channel Panning Circuit (Pan Pot)**

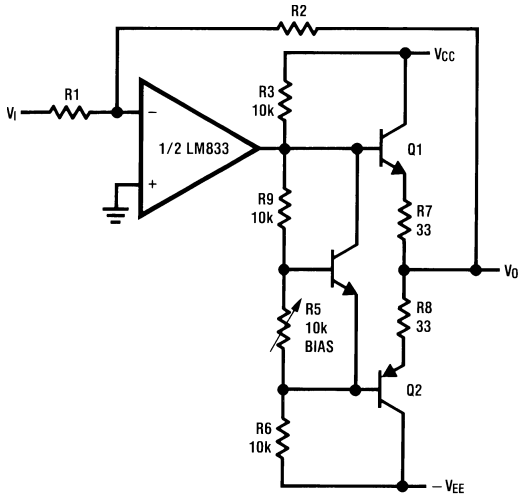
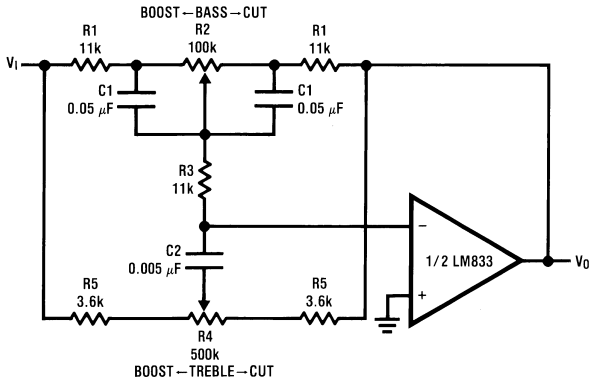



**Figure 38. Line Driver**




$$f_L = \frac{1}{2\pi R2C1}, f_{LB} = \frac{1}{2\pi R1C1}$$

$$f_H = \frac{1}{2\pi R5C2}, f_{HB} = \frac{1}{2\pi(R1 + R5 + 2R3)C2}$$

Illustration is:

$f_L$ = 32 Hz, $f_{LB}$ = 320 Hz

$f_H$ =11 kHz, $f_{HB}$ = 1.1 kHz

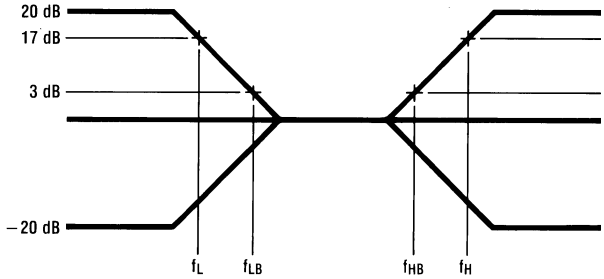
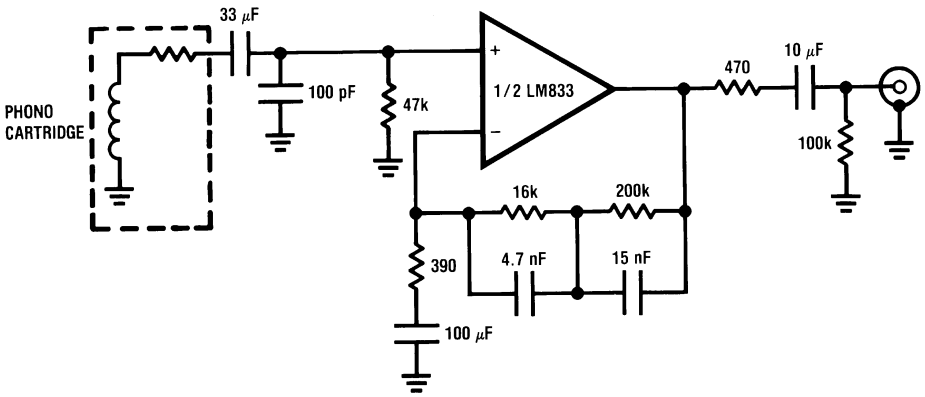



**Figure 39. Tone Control**




$A_v$ = 35 dB

$E_n$ = 0.33 μV

S/N = 90 dB

f = 1 kHz

A Weighted

A Weighted, $V_{IN}$ = 10 mV

@f = 1 kHz

**Figure 40. RIAA Preamp**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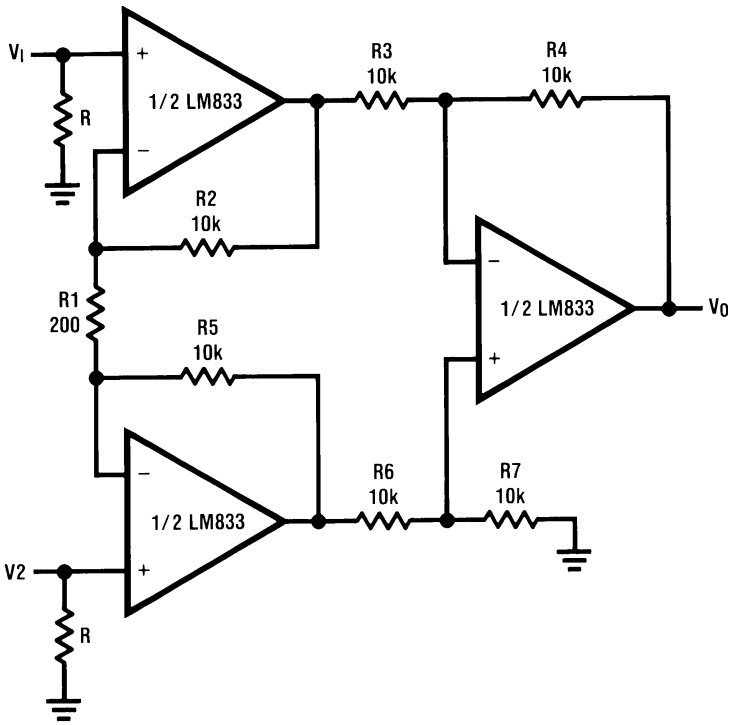


If R2 = R5, R3 = R6, R4 = R7

$$V0 = \left(1 + \frac{2R2}{R1}\right)\frac{R4}{R3}(V2 - V1)$$

Illustration is:

V0 = 101(V2 − V1)

**Figure 41. Balanced Input Mic Amp**

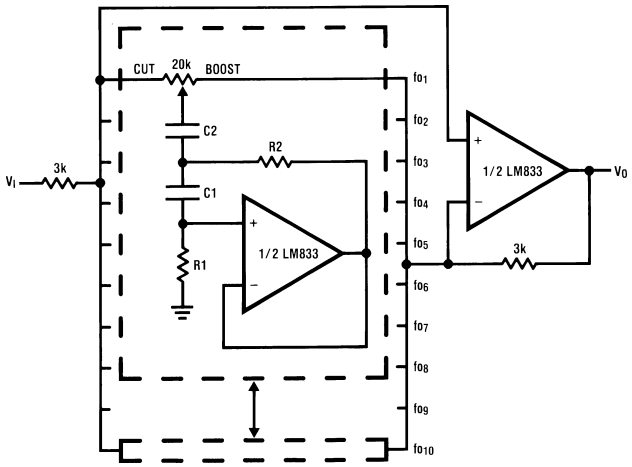


**Figure 42. 10 Band Graphic Equalizer**

| fo (Hz) | $C_1$ | $C_2$ | $R_1$ | $R_2$ |
|---|---|---|---|---|
| 32 | 0.12µF | 4.7µF | 75kΩ | 500Ω |
| 64 | 0.056µF | 3.3µF | 68kΩ | 510Ω |
| 125 | 0.033µF | 1.5µF | 62kΩ | 510Ω |
| 250 | 0.015µF | 0.82µF | 68kΩ | 470Ω |
| 500 | 8200pF | 0.39µF | 62kΩ | 470Ω |
| 1k | 3900pF | 0.22µF | 68kΩ | 470Ω |
| 2k | 2000pF | 0.1µF | 68kΩ | 470Ω |
| 4k | 1100pF | 0.056µF | 62kΩ | 470Ω |
| 8k | 510pF | 0.022µF | 68kΩ | 510Ω |
| 16k | 330pF | 0.012µF | 51kΩ | 510Ω |

**Note:** At volume of change = ±12 dB Q = 1.

## LM833-N MDC MWC DUAL AUDIO OPERATIONAL AMPLIFIER

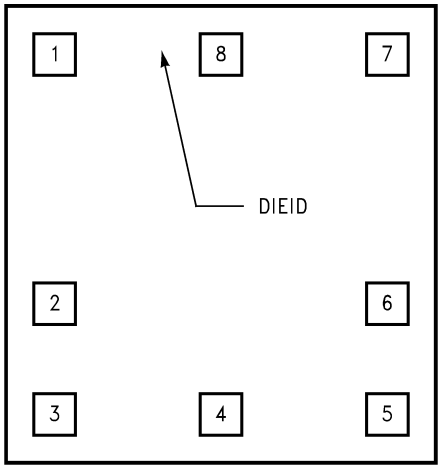


**Figure 43. Die Layout (A - Step)**


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## PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| LM833M | Active | Production | SOIC (D) \| 8 | 95 \| TUBE | No | Call TI | Call TI | -40 to 85 | LM833 M |
| LM833M.B | Active | Production | SOIC (D) \| 8 | 95 \| TUBE | No | Call TI | Call TI | -40 to 85 | LM833 M |
| LM833M/NOPB | Active | Production | SOIC (D) \| 8 | 95 \| TUBE | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | LM833 M |
| LM833M/NOPB.B | Active | Production | SOIC (D) \| 8 | 95 \| TUBE | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | LM833 M |
| LM833MM/NOPB | Active | Production | VSSOP (DGK) \| 8 | 1000 \| SMALL T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | Z83 |
| LM833MM/NOPB.B | Active | Production | VSSOP (DGK) \| 8 | 1000 \| SMALL T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | Z83 |
| LM833MMX/NOPB | Active | Production | VSSOP (DGK) \| 8 | 3500 \| LARGE T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | Z83 |
| LM833MMX/NOPB.B | Active | Production | VSSOP (DGK) \| 8 | 3500 \| LARGE T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | Z83 |
| LM833MX/NOPB | Active | Production | SOIC (D) \| 8 | 2500 \| LARGE T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | LM833 M |
| LM833MX/NOPB.B | Active | Production | SOIC (D) \| 8 | 2500 \| LARGE T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | LM833 M |
| LM833N/NOPB | Active | Production | PDIP (P) \| 8 | 40 \| TUBE | Yes | NIPDAU | Level-1-NA-UNLIM | -40 to 85 | LM 833N |
| LM833N/NOPB.B | Active | Production | PDIP (P) \| 8 | 40 \| TUBE | Yes | NIPDAU | Level-1-NA-UNLIM | -40 to 85 | LM 833N |

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts 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.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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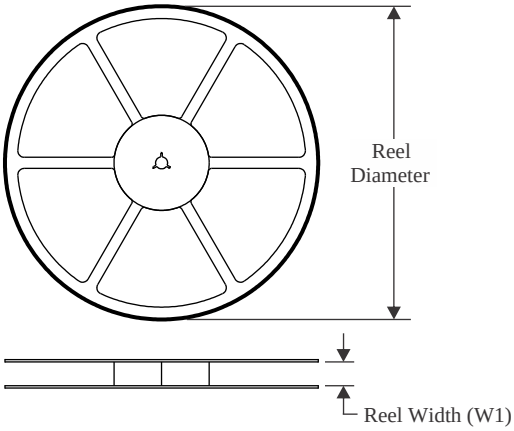
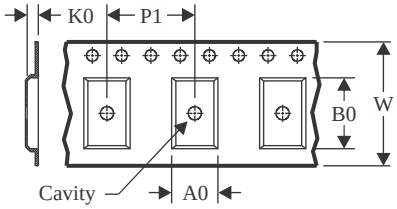
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

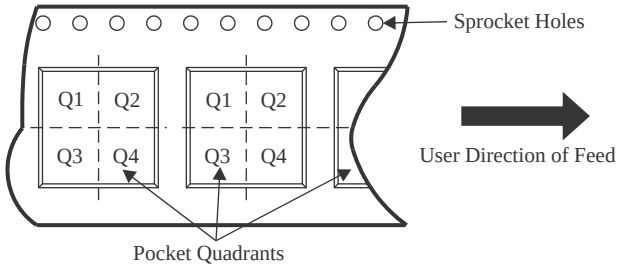



**TAPE DIMENSIONS**




| | |
|---|---|
| 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 |

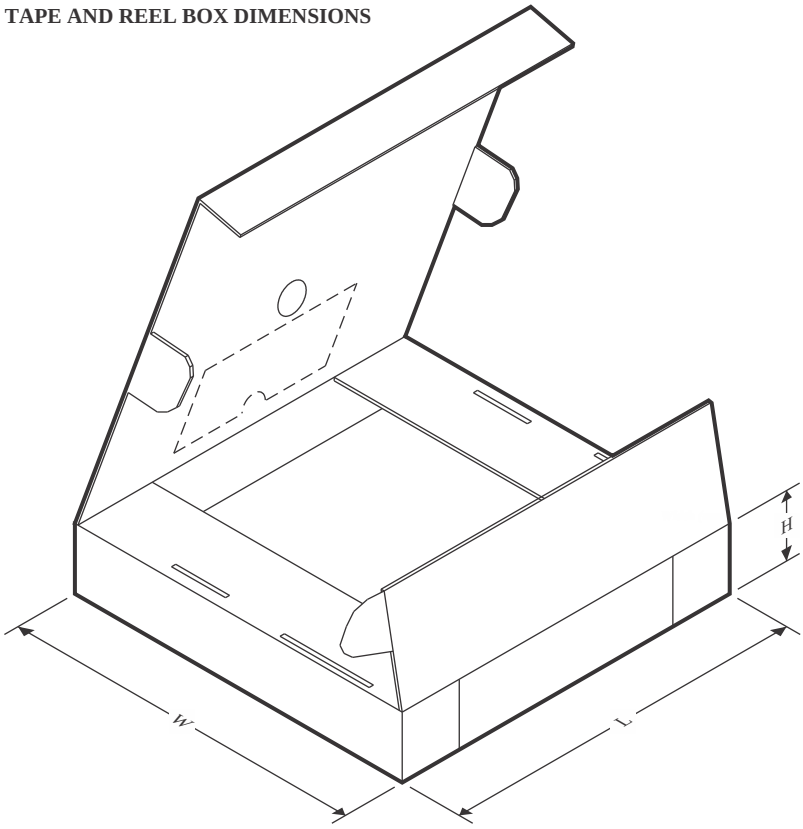
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LM833MM/NOPB | VSSOP | DGK | 8 | 1000 | 177.8 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| LM833MMX/NOPB | VSSOP | DGK | 8 | 3500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| LM833MX/NOPB | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |

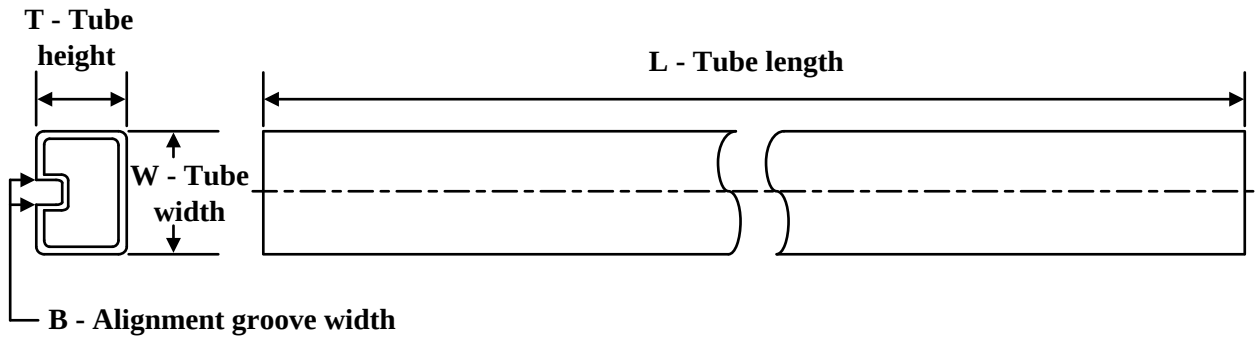
TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| LM833MM/NOPB | VSSOP | DGK | 8 | 1000 | 208.0 | 191.0 | 35.0 |
| LM833MMX/NOPB | VSSOP | DGK | 8 | 3500 | 367.0 | 367.0 | 35.0 |
| LM833MX/NOPB | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |

## TUBE




*All dimensions are nominal

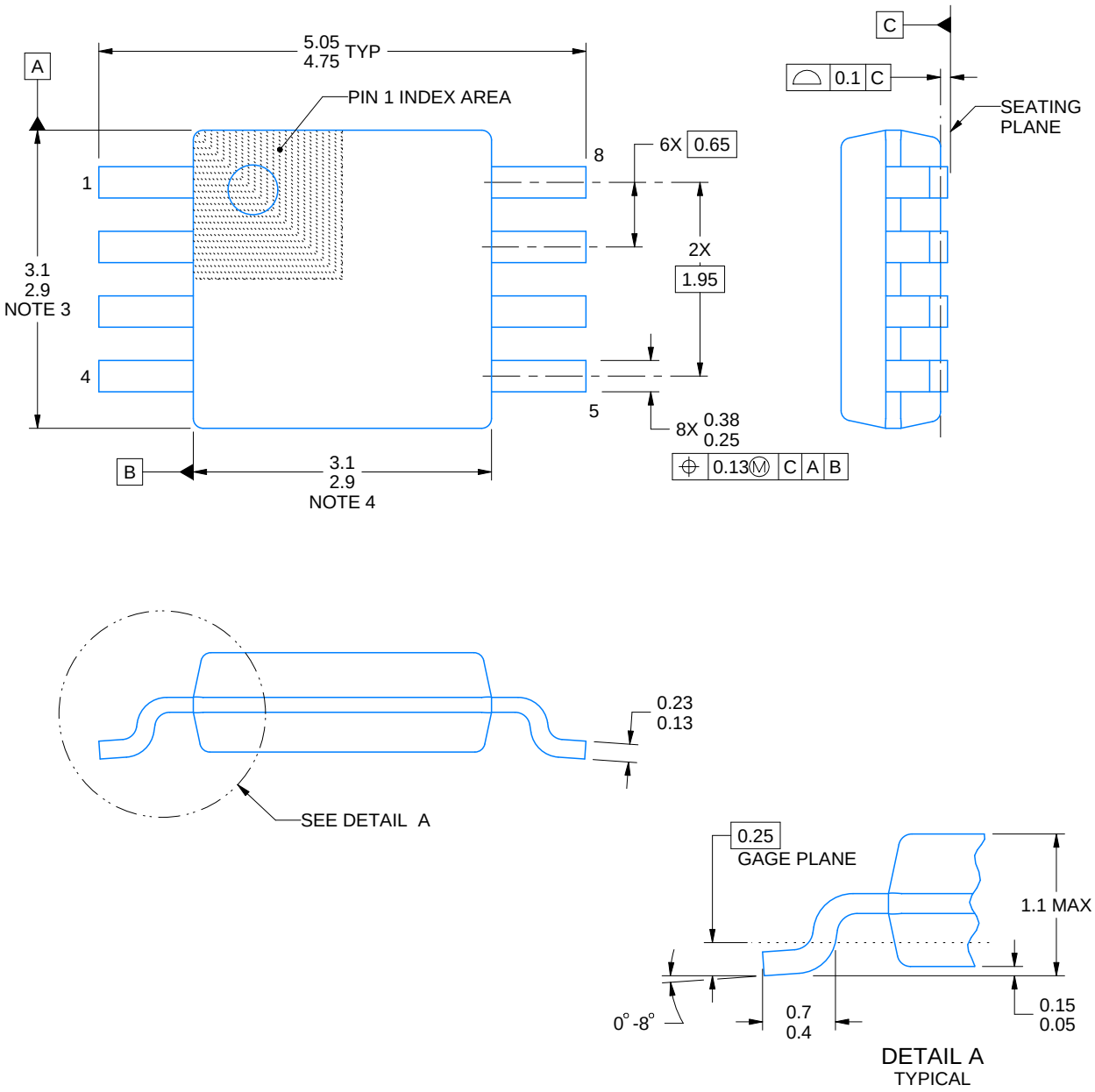
| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (µm) | B (mm) |
|---|---|---|---|---|---|---|---|---|
| LM833M | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM833M | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM833M.B | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM833M.B | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM833M/NOPB | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM833M/NOPB.B | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM833N/NOPB | P | PDIP | 8 | 40 | 502 | 14 | 11938 | 4.32 |
| LM833N/NOPB.B | P | PDIP | 8 | 40 | 502 | 14 | 11938 | 4.32 |

# PACKAGE OUTLINE

## DGK0008A

## VSSOP - 1.1 mm max height

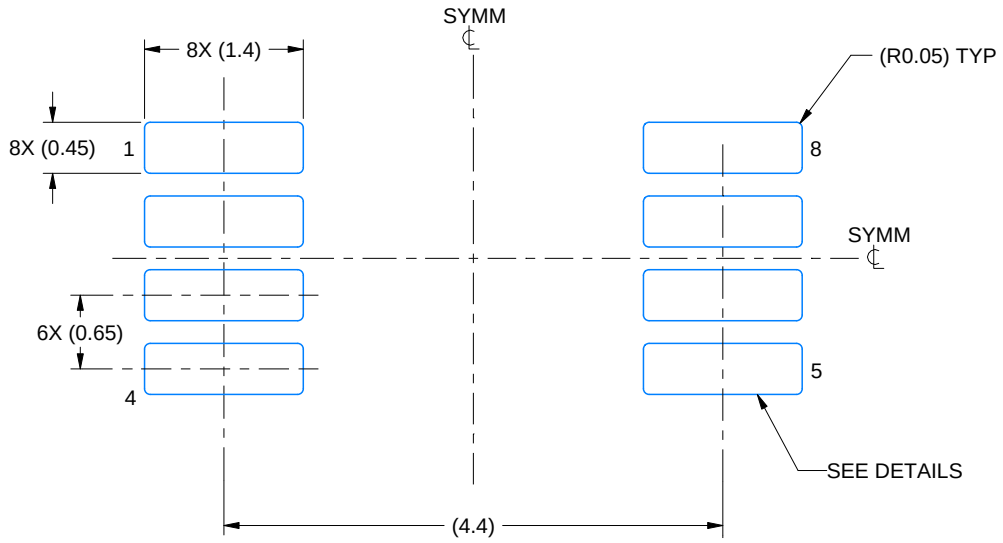
SMALL OUTLINE PACKAGE



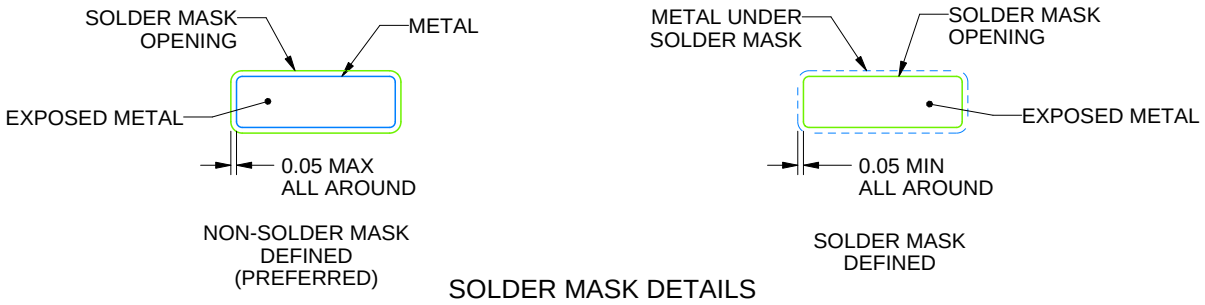

PowerPAD is a trademark of Texas Instruments.

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. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-187.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 15X

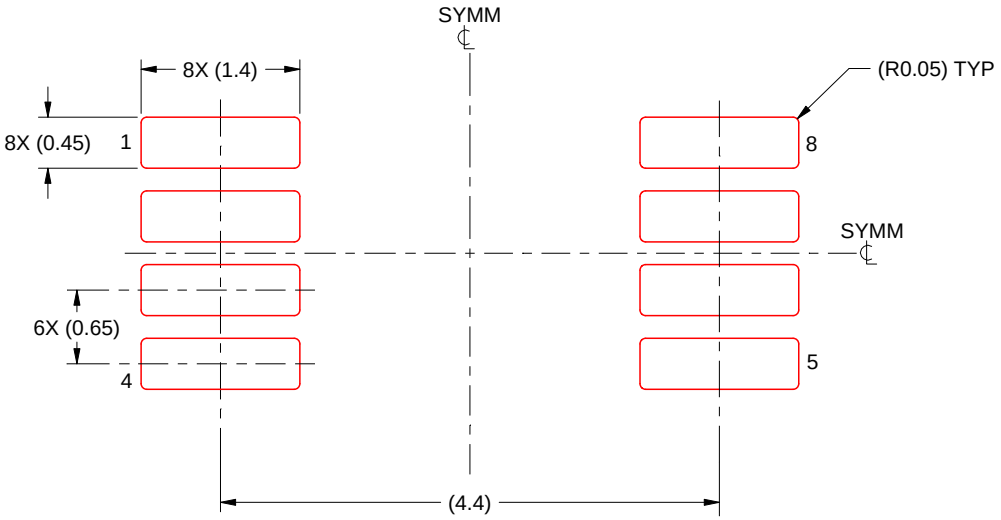



SOLDER MASK DETAILS

4214862/A 04/2023

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.
8. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.
9. Size of metal pad may vary due to creepage requirement.

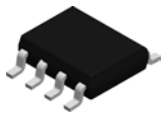



SOLDER PASTE EXAMPLE
SCALE: 15X

4214862/A 04/2023

NOTES: (continued)

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

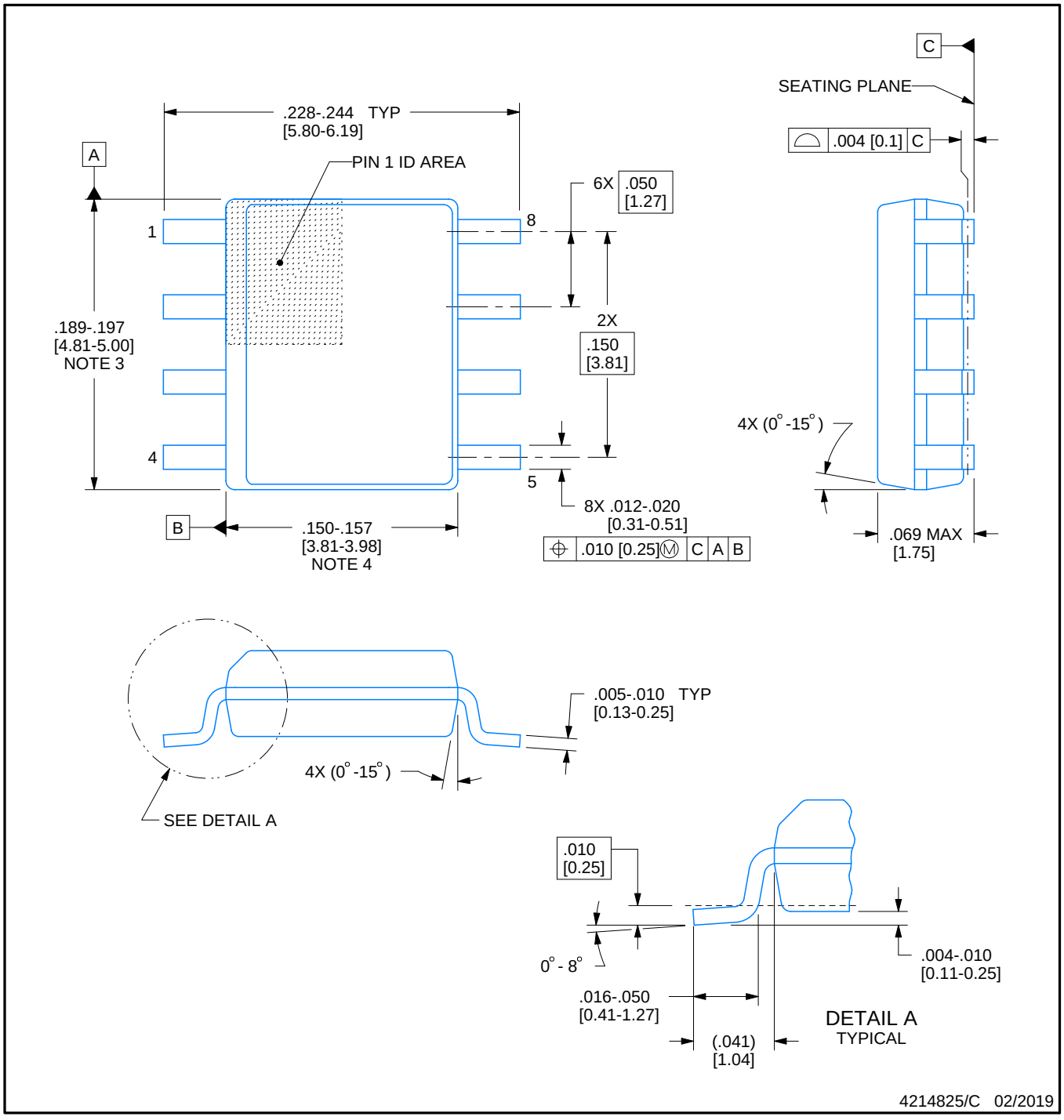


# PACKAGE OUTLINE

## D0008A

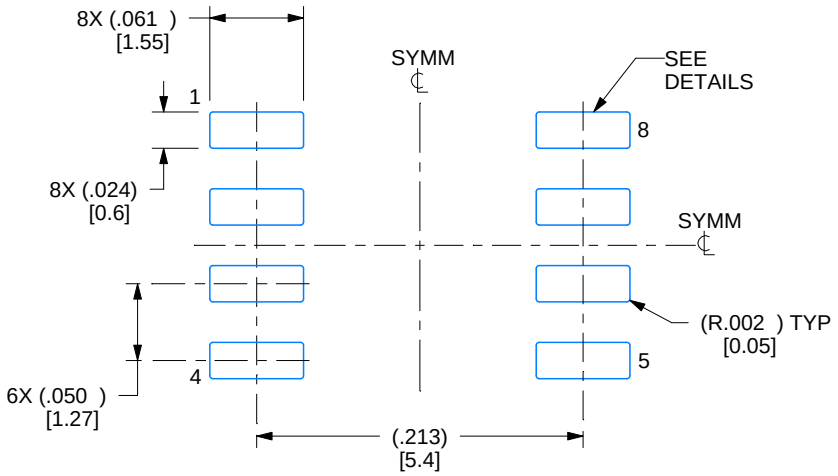
## SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

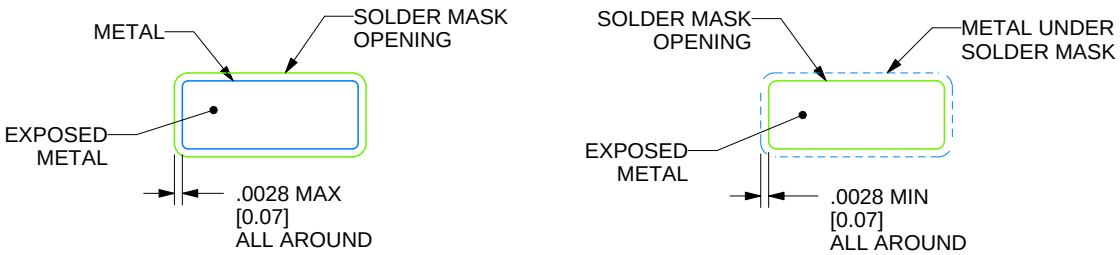



NOTES:

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)

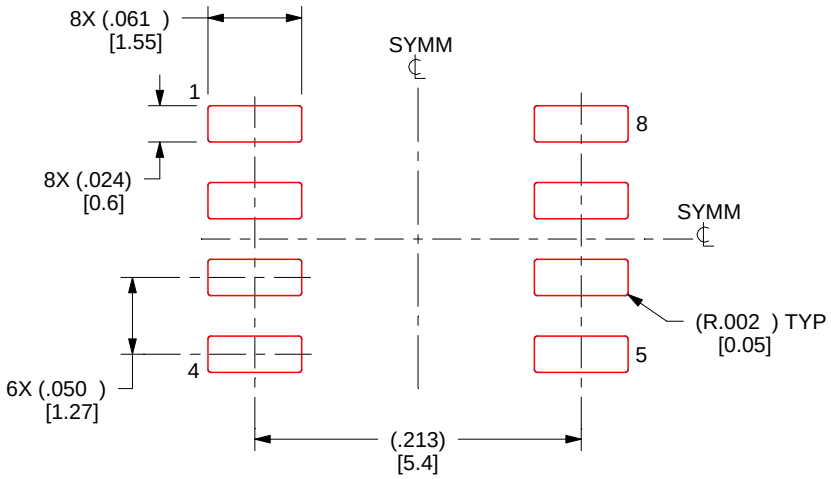
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

## D0008A

## SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



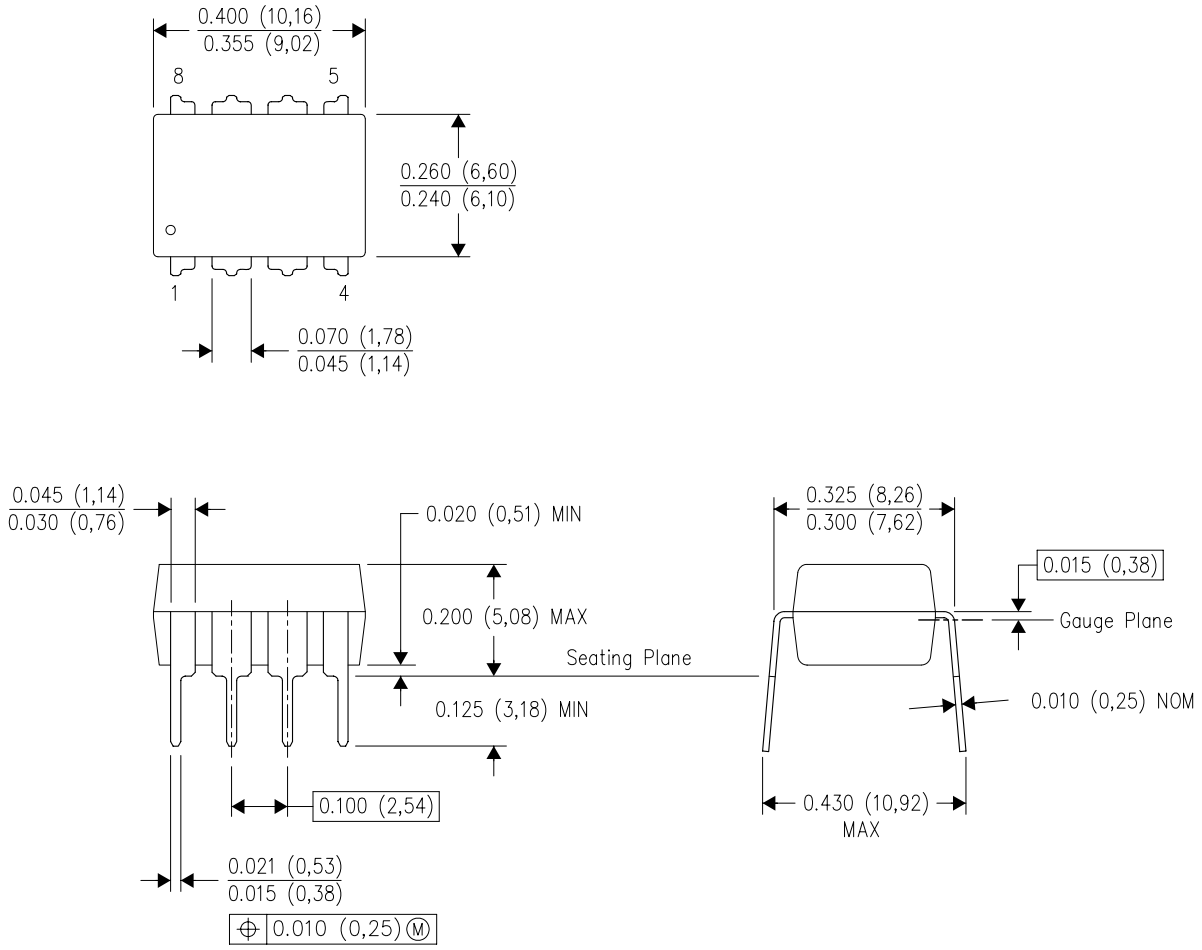

SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

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.

P (R–PDIP–T8) PLASTIC DUAL–IN–LINE PACKAGE




NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS–001 variation BA.

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