



## INA333 低功耗 (50μA)、零漂移、轨到轨输出仪表放大器

### 1 特性

- 低偏移电压: 25μV (最大值),  $G \geq 100$
- 低漂移: 0.1μV/°C,  $G \geq 100$
- 低噪声: 50nV/√Hz,  $G \geq 100$
- 高共模抑制比 (CMRR): 100dB (最小值),  $G \geq 10$
- 低输入偏置电流: 200pA (最大值)
- 电源范围: 1.8V 至 5.5V
- 输入电压: (V-) + 0.1V 至 (V+) - 0.1V
- 输出电压: (V-) + 0.05V 至 (V+) - 0.05V
- 低静态电流: 50μA
- 工作温度范围: -40°C 至 +125°C
- 已过滤射频干扰 (RFI) 的输入
- 8 引脚 VSSOP 和 8 引脚 WSON 封装

### 2 应用范围

- 桥式放大器
- 心电图 (ECG) 放大器
- 压力传感器
- 医疗仪表
- 便携式仪表
- 衡器
- 热电偶放大器
- 电阻式温度检测器 (RTD) 传感器放大器
- 数据采集

### 3 说明

INA333 器件是一款低功耗的精密仪表放大器, 具有出色的精度。该器件采用通用的三运算放大器设计, 并且拥有小巧尺寸和低功耗特性, 非常适合各类便携式应用。

可通过单个外部电阻在 1 到 1000 范围内设置增益。

INA333 设计为采用符合行业标准的增益公式:  $G = 1 + (100\text{k}\Omega/R_G)$ 。

INA333 器件拥有超低的偏移电压 (25μV,  $G \geq 100$ ), 出色的偏移电压漂移

(0.1μV/°C,  $G \geq 100$ ), 以及较高的共模抑制比 (100dB,  $G \geq 10$ )。该器件可由低至 1.8V (±0.9V) 的电源供电运行, 静态电流仅为 50μA, 因此非常适合电池供电类系统。INA333 器件采用自动校准技术在扩展工业温度范围内保证了出色的精度, 同时还提供了向下扩展至直流的超低噪声密度 (50nV/√Hz)。

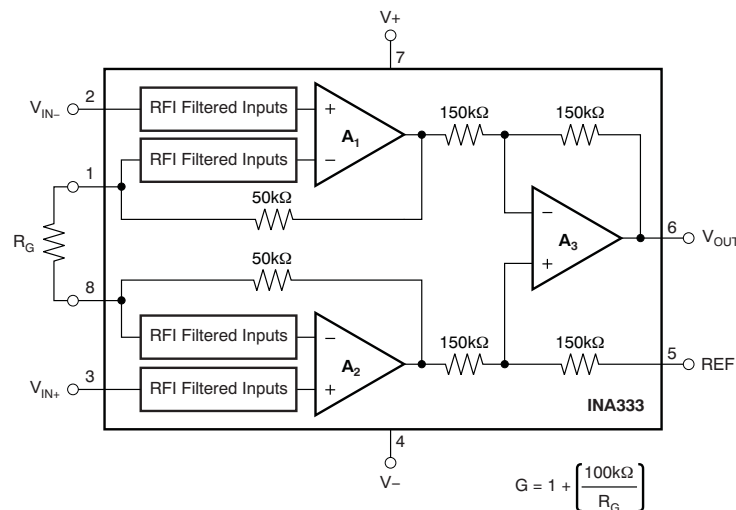
INA333 器件采用 8 引脚 VSSOP 和 WSON 表面贴装封装, 额定温度范围  $T_A = -40^\circ\text{C}$  至 +125°C。

器件信息<sup>(1)</sup>

| 器件型号   | 封装        | 封装尺寸 (标称值)      |
|--------|-----------|-----------------|
| INA333 | VSSOP (8) | 3.00mm × 3.00mm |
|        | WSON (8)  | 3.00mm × 3.00mm |

(1) 要了解所有可用封装, 请见数据表末尾的可订购产品附录。

简化电路原理图



## 目录

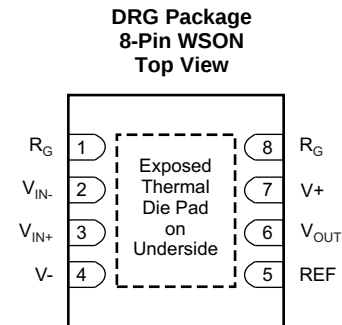
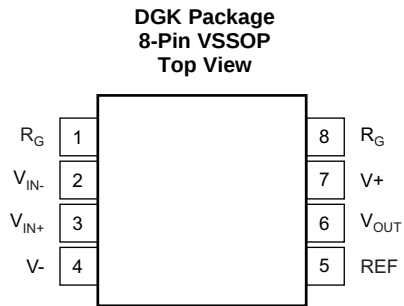
|          |                                              |           |           |                                             |           |
|----------|----------------------------------------------|-----------|-----------|---------------------------------------------|-----------|
| <b>1</b> | <b>特性</b> .....                              | <b>1</b>  | 7.4       | Device Functional Modes.....                | <b>13</b> |
| <b>2</b> | <b>应用范围</b> .....                            | <b>1</b>  | <b>8</b>  | <b>Application and Implementation</b> ..... | <b>14</b> |
| <b>3</b> | <b>说明</b> .....                              | <b>1</b>  | 8.1       | Application Information.....                | <b>14</b> |
| <b>4</b> | <b>修订历史记录</b> .....                          | <b>2</b>  | 8.2       | Typical Application .....                   | <b>14</b> |
| <b>5</b> | <b>Pin Configuration and Functions</b> ..... | <b>3</b>  | <b>9</b>  | <b>Power Supply Recommendations</b> .....   | <b>19</b> |
| <b>6</b> | <b>Specifications</b> .....                  | <b>4</b>  | <b>10</b> | <b>Layout</b> .....                         | <b>20</b> |
| 6.1      | Absolute Maximum Ratings .....               | <b>4</b>  | 10.1      | Layout Guidelines .....                     | <b>20</b> |
| 6.2      | ESD Ratings.....                             | <b>4</b>  | 10.2      | Layout Example .....                        | <b>20</b> |
| 6.3      | Recommended Operating Conditions.....        | <b>4</b>  | <b>11</b> | <b>器件和文档支持</b> .....                        | <b>21</b> |
| 6.4      | Thermal Information .....                    | <b>4</b>  | 11.1      | 器件支持 .....                                  | <b>21</b> |
| 6.5      | Electrical Characteristics.....              | <b>5</b>  | 11.2      | 文档支持 .....                                  | <b>22</b> |
| 6.6      | Typical Characteristics .....                | <b>7</b>  | 11.3      | 商标.....                                     | <b>22</b> |
| <b>7</b> | <b>Detailed Description</b> .....            | <b>13</b> | 11.4      | 静电放电警告.....                                 | <b>22</b> |
| 7.1      | Overview .....                               | <b>13</b> | 11.5      | Glossary .....                              | <b>23</b> |
| 7.2      | Functional Block Diagram .....               | <b>13</b> | <b>12</b> | <b>机械、封装和可订购信息</b> .....                    | <b>23</b> |
| 7.3      | Feature Description.....                     | <b>13</b> |           |                                             |           |

## 4 修订历史记录

注：之前版本的页码可能与当前版本有所不同。

| Changes from Revision B (October 2008) to Revision C                                | Page     |
|-------------------------------------------------------------------------------------|----------|
| • 已添加 ESD 额定值表，特性 描述 部分，器件功能模式，应用和实施部分，电源相关建议部分，布局部分，器件和文档支持部分以及机械、封装和可订购信息部分 ..... | <b>1</b> |

## 5 Pin Configuration and Functions



### Pin Functions

| PIN              |      | I/O | DESCRIPTION                                                                              |
|------------------|------|-----|------------------------------------------------------------------------------------------|
| NAME             | NO.  |     |                                                                                          |
| REF              | 5    | I   | Reference input. This pin must be driven by low impedance or connected to ground.        |
| R <sub>G</sub>   | 1, 8 | —   | Gain setting pins. For gains greater than 1, place a gain resistor between pins 1 and 8. |
| V <sup>+</sup>   | 7    | —   | Positive supply                                                                          |
| V <sup>-</sup>   | 4    | —   | Negative supply                                                                          |
| V <sub>IN+</sub> | 3    | I   | Positive input                                                                           |
| V <sub>IN-</sub> | 2    | I   | Negative input                                                                           |
| V <sub>OUT</sub> | 6    | O   | Output                                                                                   |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) <sup>(1)</sup>

|                                       | MIN                     | MAX                     | UNIT |
|---------------------------------------|-------------------------|-------------------------|------|
| Supply voltage                        | 7                       |                         | V    |
| Analog input voltage <sup>(2)</sup>   | (V <sub>-</sub> ) – 0.3 | (V <sub>+</sub> ) + 0.3 | V    |
| Output short-circuit <sup>(3)</sup>   | Continuous              |                         |      |
| Operating temperature, T <sub>A</sub> | –40                     | 150                     | °C   |
| Junction temperature, T <sub>J</sub>  |                         | 150                     | °C   |
| Storage temperature, T <sub>stg</sub> | –65                     | 150                     | °C   |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) Input pins are diode-clamped to the power-supply rails. Input signals that can swing more than 0.3 V beyond the supply rails should be current limited to 10 mA or less.
- (3) Short-circuit to ground.

### 6.2 ESD Ratings

|                                            |                                                                                | VALUE | UNIT |
|--------------------------------------------|--------------------------------------------------------------------------------|-------|------|
| V <sub>(ESD)</sub> Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>              | ±4000 | V    |
|                                            | Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup> | ±1000 |      |
|                                            | Machine model (MM)                                                             | ±200  |      |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

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

|                               | MIN | MAX | UNIT |
|-------------------------------|-----|-----|------|
| V <sub>S</sub> Supply voltage | 1.8 | 5.5 | V    |
| Specified temperature         | –40 | 125 | °C   |

### 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | INA333      |            | UNIT |
|-------------------------------|----------------------------------------------|-------------|------------|------|
|                               |                                              | DGK (VSSOP) | DRG (WSON) |      |
|                               |                                              | 8 PINS      | 8 PINS     |      |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | 169.5       | 60         | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    | 62.7        | 60         | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         | 90.3        | 50         | °C/W |
| Ψ <sub>JT</sub>               | Junction-to-top characterization parameter   | 7.6         | —          | °C/W |
| Ψ <sub>JB</sub>               | Junction-to-board characterization parameter | 88.7        | —          | °C/W |
| R <sub>θJC(bot)</sub>         | Junction-to-case (bottom) thermal resistance | —           | 6          | °C/W |

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](http://www.ti.com/lit/zip/spra953).

## 6.5 Electrical Characteristics

for  $V_S = 1.8 \text{ V}$  to  $5.5 \text{ V}$  at  $T_A = 25^\circ\text{C}$ ,  $R_L = 10 \text{ k}\Omega$ ,  $V_{REF} = V_S / 2$ , and  $G = 1$  (unless otherwise noted)

| PARAMETER            |                                           | TEST CONDITIONS                                                           | MIN        | TYP                                | MAX           | UNIT             |
|----------------------|-------------------------------------------|---------------------------------------------------------------------------|------------|------------------------------------|---------------|------------------|
| INPUT <sup>(1)</sup> |                                           |                                                                           |            |                                    |               |                  |
| V <sub>OSI</sub>     | Offset voltage, RTI <sup>(2)</sup>        |                                                                           |            | ±10 ±25/G                          | ±25 ±75/G     | μV               |
| PSR                  | vs temperature                            | T <sub>A</sub> = −40°C to +125°C                                          |            |                                    | ±0.1 ±0.5 / G | μV/°C            |
|                      | vs power supply                           | 1.8 V ≤ V <sub>S</sub> ≤ 5.5 V                                            |            | ±1 ±5/G                            | ±5 ±15/G      | μV/V             |
|                      | Long-term stability                       |                                                                           |            | See <sup>(3)</sup>                 |               |                  |
|                      | Turnon time to specified V <sub>OSI</sub> | T <sub>A</sub> = −40°C to +125°C                                          |            | See <i>Typical Characteristics</i> |               |                  |
|                      | Impedance                                 |                                                                           |            |                                    |               |                  |
| Z <sub>IN</sub>      | Differential                              |                                                                           |            | 100    3                           |               | GΩ    pF         |
| Z <sub>IN</sub>      | Common-mode                               |                                                                           |            | 100    3                           |               | GΩ    pF         |
| V <sub>CM</sub>      | Common-mode voltage range                 | V <sub>O</sub> = 0 V                                                      | (V−) + 0.1 |                                    | (V+) − 0.1    | V                |
| CMR                  | Common-mode rejection                     | DC to 60 Hz                                                               |            |                                    |               |                  |
|                      | G = 1                                     | V <sub>CM</sub> = (V−) + 0.1 V<br>to (V+) − 0.1 V                         | 80         | 90                                 |               | dB               |
|                      | G = 10                                    | V <sub>CM</sub> = (V−) + 0.1 V<br>to (V+) − 0.1 V                         | 100        | 110                                |               | dB               |
|                      | G = 100                                   | V <sub>CM</sub> = (V−) + 0.1 V<br>to (V+) − 0.1 V                         | 100        | 115                                |               | dB               |
|                      | G = 1000                                  | V <sub>CM</sub> = (V−) + 0.1 V<br>to (V+) − 0.1 V                         | 100        | 115                                |               | dB               |
| INPUT BIAS CURRENT   |                                           |                                                                           |            |                                    |               |                  |
| I <sub>B</sub>       | Input bias current                        |                                                                           |            | ±70                                | ±200          | pA               |
|                      | vs temperature                            | T <sub>A</sub> = −40°C to +125°C                                          |            | See <a href="#">Figure 26</a>      |               | pA/°C            |
| I <sub>OS</sub>      | Input offset current                      |                                                                           |            | ±50                                | ±200          | pA               |
|                      | vs temperature                            | T <sub>A</sub> = −40°C to +125°C                                          |            | See <a href="#">Figure 28</a>      |               | pA/°C            |
| INPUT VOLTAGE NOISE  |                                           |                                                                           |            |                                    |               |                  |
| e <sub>NI</sub>      | Input voltage noise                       | G = 100, R <sub>S</sub> = 0 Ω, f = 10 Hz                                  |            | 50                                 |               | nV/√Hz           |
|                      |                                           | G = 100, R <sub>S</sub> = 0 Ω, f = 100 Hz                                 |            | 50                                 |               | nV/√Hz           |
|                      |                                           | G = 100, R <sub>S</sub> = 0 Ω, f = 1 kHz                                  |            | 50                                 |               | nV/√Hz           |
|                      |                                           | G = 100, R <sub>S</sub> = 0 Ω, f = 0.1 Hz to 10 Hz                        |            | 1                                  |               | μV <sub>PP</sub> |
| i <sub>N</sub>       | Input current noise                       | f = 10 Hz                                                                 |            | 100                                |               | fA/√Hz           |
|                      |                                           | f = 0.1 Hz to 10 Hz                                                       |            | 2                                  |               | pA <sub>PP</sub> |
| GAIN                 |                                           |                                                                           |            |                                    |               |                  |
| G                    | Gain equation                             |                                                                           |            | 1 + (100 kΩ/R <sub>G</sub> )       |               | V/V              |
|                      | Range of gain                             |                                                                           | 1          |                                    | 1000          | V/V              |
| Gain error           |                                           | V <sub>S</sub> = 5.5 V, (V−) + 100 mV<br>≤ V <sub>O</sub> ≤ (V+) − 100 mV |            |                                    |               |                  |
|                      |                                           | G = 1                                                                     |            | ±0.01%                             | ±0.1%         |                  |
|                      |                                           | G = 10                                                                    |            | ±0.05%                             | ±0.25%        |                  |
|                      |                                           | G = 100                                                                   |            | ±0.07%                             | ±0.25%        |                  |
|                      |                                           | G = 1000                                                                  |            | ±0.25%                             | ±0.5%         |                  |
|                      | Gain vs temperature, G = 1                | T <sub>A</sub> = −40°C to +125°C                                          |            | ±1                                 | ±5            | ppm/°C           |
|                      | Gain vs temperature, G > 1 <sup>(4)</sup> | T <sub>A</sub> = −40°C to +125°C                                          |            | ±15                                | ±50           | ppm/°C           |
|                      | Gain nonlinearity                         | V <sub>S</sub> = 5.5 V, (V−) + 100 mV<br>≤ V <sub>O</sub> ≤ (V+) − 100 mV |            |                                    |               |                  |
|                      | Gain nonlinearity, G = 1 to 1000          | R <sub>L</sub> = 10 kΩ                                                    |            | 10                                 |               | ppm              |
| OUTPUT               |                                           |                                                                           |            |                                    |               |                  |
|                      | Output voltage swing from rail            | V <sub>S</sub> = 5.5 V, R <sub>L</sub> = 10 kΩ                            |            | See <a href="#">Figure 29</a>      | 50            | mV               |
|                      | Capacitive load drive                     |                                                                           |            | 500                                |               | pF               |
| I <sub>SC</sub>      | Short-circuit current                     | Continuous to common                                                      |            | −40, +5                            |               | mA               |

(1) Total  $V_{OS}$ , referred-to-input =  $(V_{OSI}) + (V_{OSO} / G)$

(2) RTI = Referred-to-input

(3) 300-hour life test at  $150^\circ\text{C}$  demonstrated randomly distributed variation of approximately  $1 \mu\text{V}$

(4) Does not include effects of external resistor  $R_G$

**INA333**

ZHCSAK0C – JULY 2008 – REVISED DECEMBER 2015

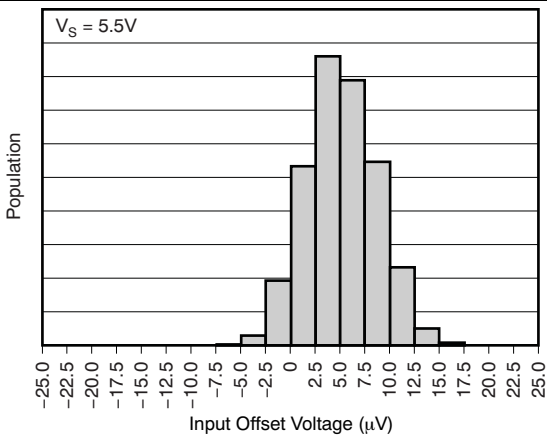
[www.ti.com.cn](http://www.ti.com.cn)
**Electrical Characteristics (continued)**

 for  $V_S = 1.8\text{ V}$  to  $5.5\text{ V}$  at  $T_A = 25^\circ\text{C}$ ,  $R_L = 10\text{ k}\Omega$ ,  $V_{REF} = V_S / 2$ , and  $G = 1$  (unless otherwise noted)

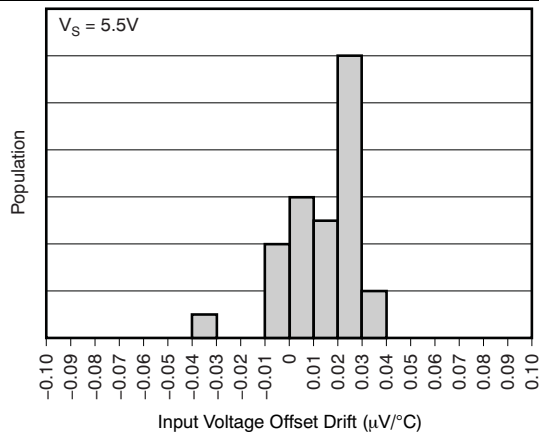
| PARAMETER                     |                   | TEST CONDITIONS                                          | MIN       | TYP  | MAX        | UNIT             |
|-------------------------------|-------------------|----------------------------------------------------------|-----------|------|------------|------------------|
| <b>FREQUENCY RESPONSE</b>     |                   |                                                          |           |      |            |                  |
| Bandwidth, –3dB               |                   | $G = 1$                                                  |           | 150  |            | kHz              |
|                               |                   | $G = 10$                                                 |           | 35   |            | kHz              |
|                               |                   | $G = 100$                                                |           | 3.5  |            | kHz              |
|                               |                   | $G = 1000$                                               |           | 350  |            | Hz               |
| SR Slew rate                  |                   | $V_S = 5\text{ V}$ , $V_O = 4\text{-V step}$ , $G = 1$   |           | 0.16 |            | V/ $\mu\text{s}$ |
|                               |                   | $V_S = 5\text{ V}$ , $V_O = 4\text{-V step}$ , $G = 100$ |           | 0.05 |            | V/ $\mu\text{s}$ |
| $t_S$ Settling time to 0.01%  |                   | $V_{STEP} = 4\text{ V}$ , $G = 1$                        |           | 50   |            | $\mu\text{s}$    |
|                               |                   | $V_{STEP} = 4\text{ V}$ , $G = 100$                      |           | 400  |            | $\mu\text{s}$    |
| $t_S$ Settling time to 0.001% |                   | $V_{STEP} = 4\text{ V}$ , $G = 1$                        |           | 60   |            | $\mu\text{s}$    |
|                               |                   | $V_{STEP} = 4\text{ V}$ , $G = 100$                      |           | 500  |            | $\mu\text{s}$    |
| Overload recovery             |                   | 50% overdrive                                            |           | 75   |            | $\mu\text{s}$    |
| <b>REFERENCE INPUT</b>        |                   |                                                          |           |      |            |                  |
| $R_{IN}$                      |                   |                                                          |           | 300  |            | k $\Omega$       |
| Voltage range                 |                   |                                                          | $V^-$     |      | $V^+$      | V                |
| <b>POWER SUPPLY</b>           |                   |                                                          |           |      |            |                  |
| Voltage range                 |                   | Single voltage range                                     | +1.8      |      | +5.5       | V                |
|                               |                   | Dual voltage range                                       | $\pm 0.9$ |      | $\pm 2.75$ | V                |
| $I_Q$                         | Quiescent current | $V_{IN} = V_S / 2$                                       |           | 50   | 75         | $\mu\text{A}$    |
|                               | vs temperature    | $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$        |           |      | 80         | $\mu\text{A}$    |
| <b>TEMPERATURE RANGE</b>      |                   |                                                          |           |      |            |                  |
| Specified temperature range   |                   |                                                          | –40       |      | 125        | $^\circ\text{C}$ |
| Operating temperature range   |                   |                                                          | –40       |      | 150        | $^\circ\text{C}$ |

## 6.6 Typical Characteristics

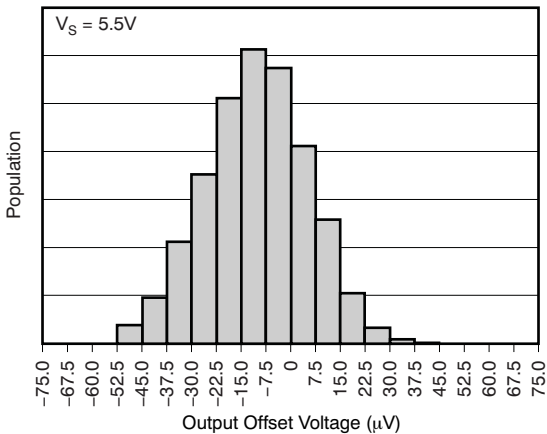
at  $T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{ V}$ ,  $R_L = 10\text{ k}\Omega$ ,  $V_{\text{REF}} = \text{midsupply}$ , and  $G = 1$  (unless otherwise noted)



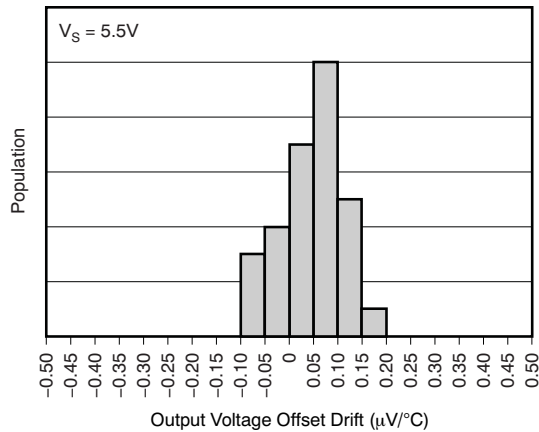
**Figure 1. Input Offset Voltage**



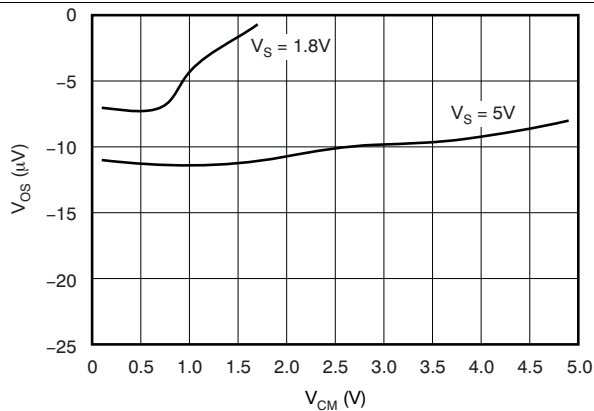
**Figure 2. Input Voltage Offset Drift ( $-40^\circ\text{C}$  to  $125^\circ\text{C}$ )**



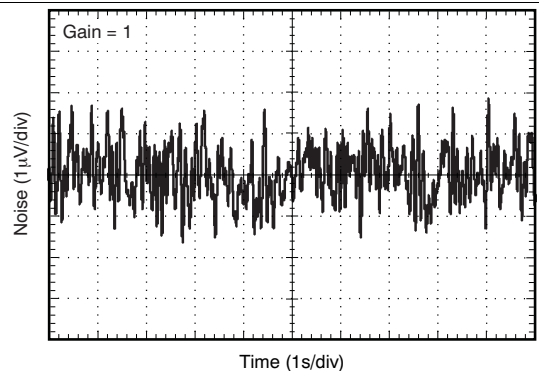
**Figure 3. Output Offset Voltage**



**Figure 4. Output Voltage Offset Drift ( $-40^\circ\text{C}$  to  $125^\circ\text{C}$ )**



**Figure 5. Offset Voltage vs Common-Mode Voltage**



**Figure 6. 0.1-Hz to 10-Hz Noise**

## Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{ V}$ ,  $R_L = 10\text{ k}\Omega$ ,  $V_{\text{REF}} = \text{mid supply}$ , and  $G = 1$  (unless otherwise noted)

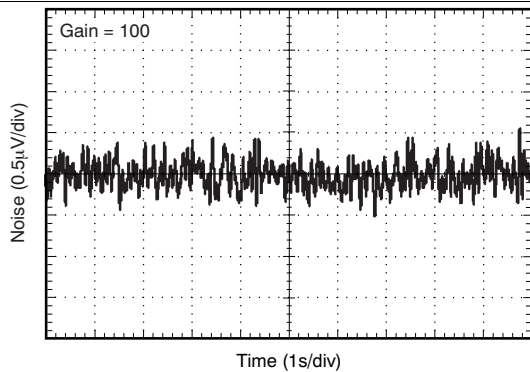


Figure 7. 0.1-Hz to 10-Hz Noise

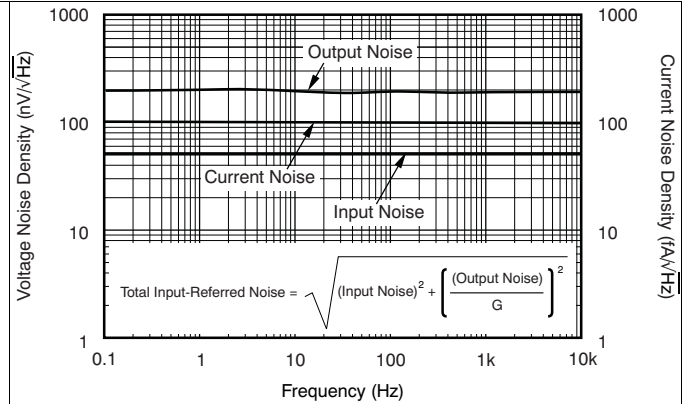


Figure 8. Spectral Noise Density

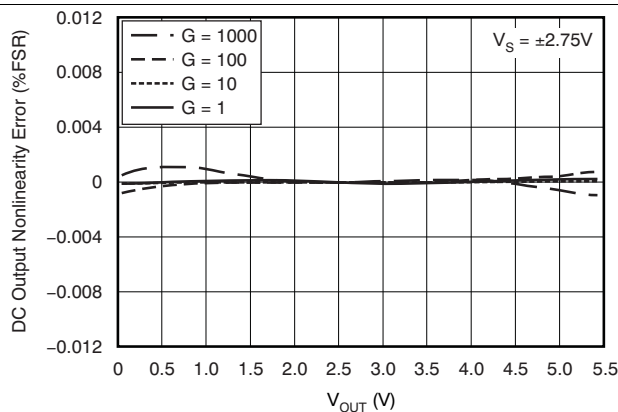


Figure 9. Nonlinearity Error

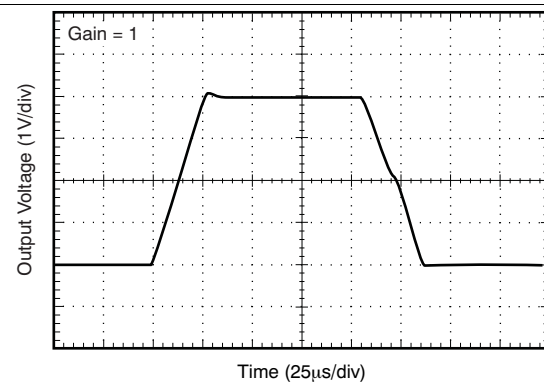


Figure 10. Large Signal Response

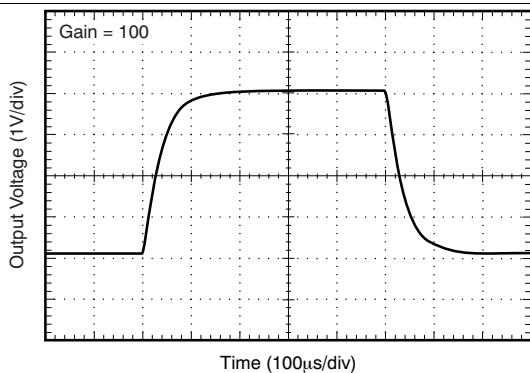


Figure 11. Large-Signal Step Response

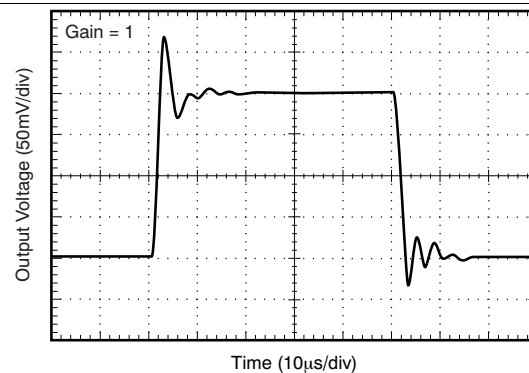
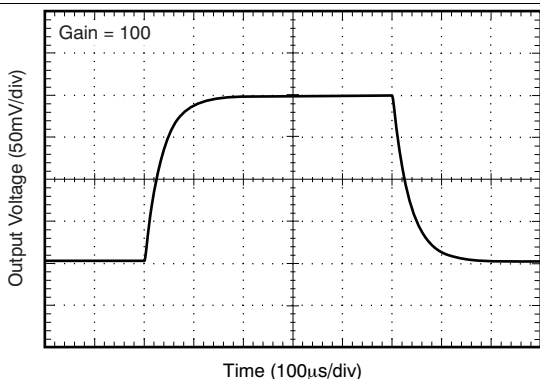


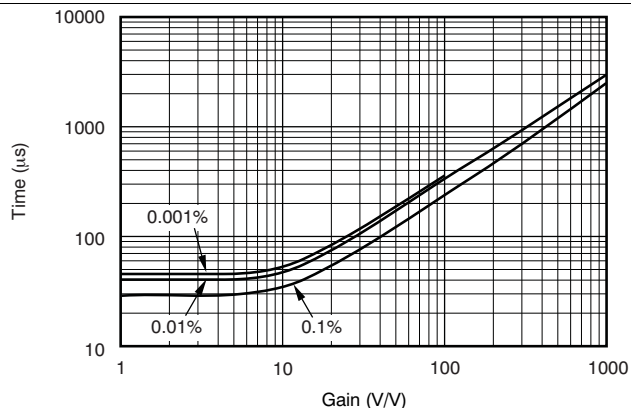
Figure 12. Small-Signal Step Response

## Typical Characteristics (continued)

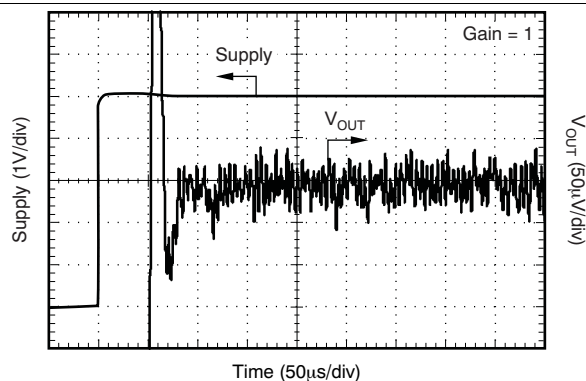
at  $T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{ V}$ ,  $R_L = 10\text{ k}\Omega$ ,  $V_{\text{REF}} = \text{mid supply}$ , and  $G = 1$  (unless otherwise noted)



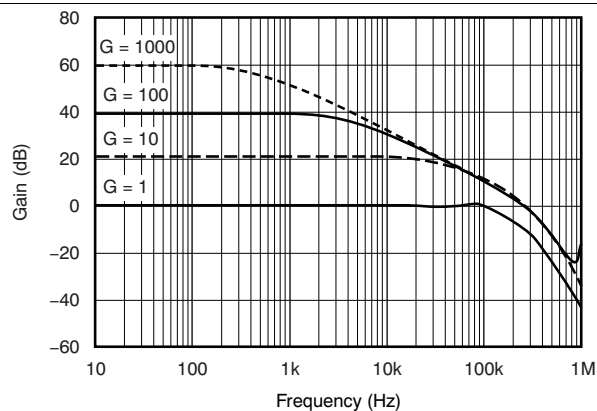
**Figure 13. Small-Signal Step Response**



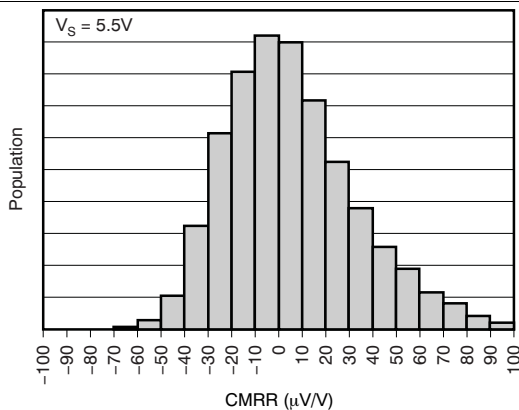
**Figure 14. Settling Time vs Gain**



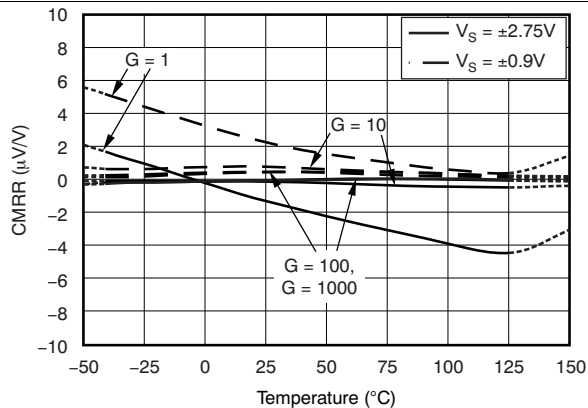
**Figure 15. Start-Up Settling Time**



**Figure 16. Gain vs Frequency**



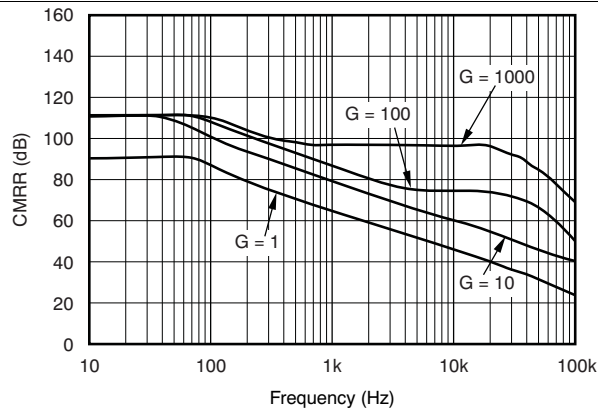
**Figure 17. Common-Mode Rejection Ratio**



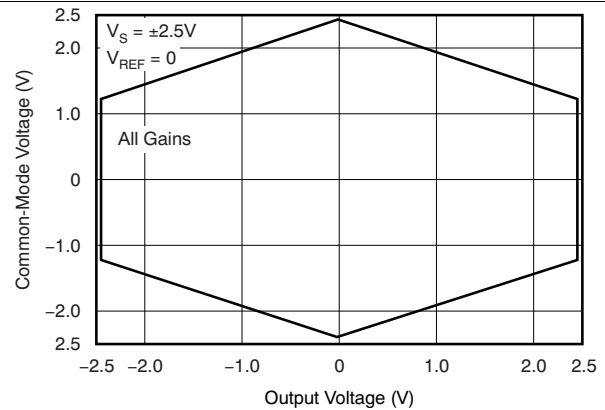
**Figure 18. Common-Mode Rejection Ratio vs Temperature**

## Typical Characteristics (continued)

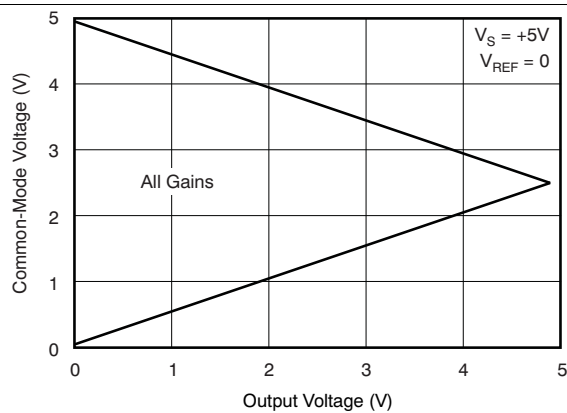
at  $T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{ V}$ ,  $R_L = 10\text{ k}\Omega$ ,  $V_{\text{REF}} = \text{midsupply}$ , and  $G = 1$  (unless otherwise noted)



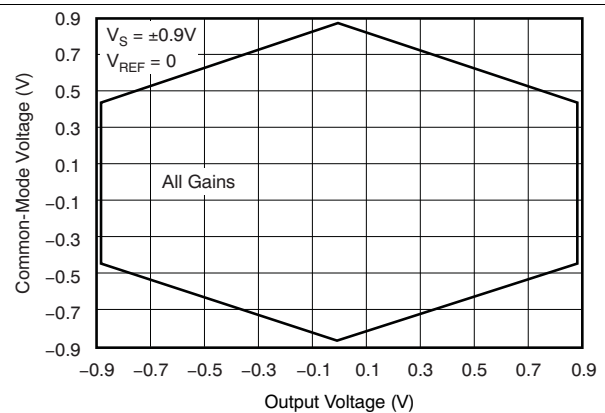
**Figure 19. Common-Mode Rejection Ratio vs Frequency**



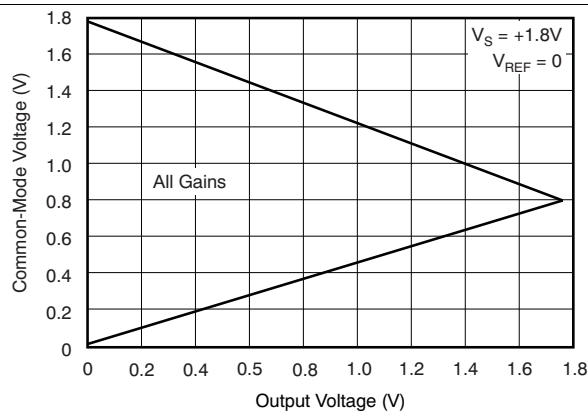
**Figure 20. Typical Common-Mode Range vs Output Voltage**



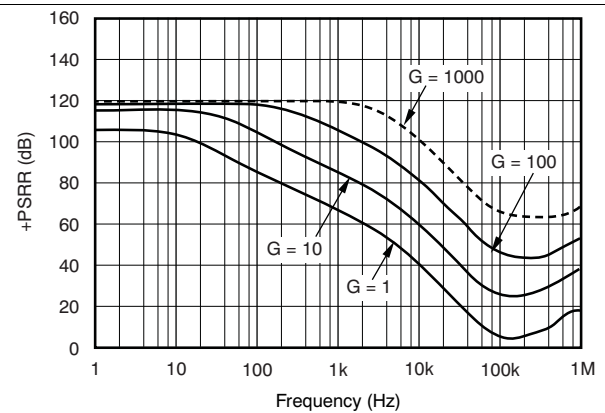
**Figure 21. Typical Common-Mode Range vs Output Voltage**



**Figure 22. Typical Common-Mode Range vs Output Voltage**



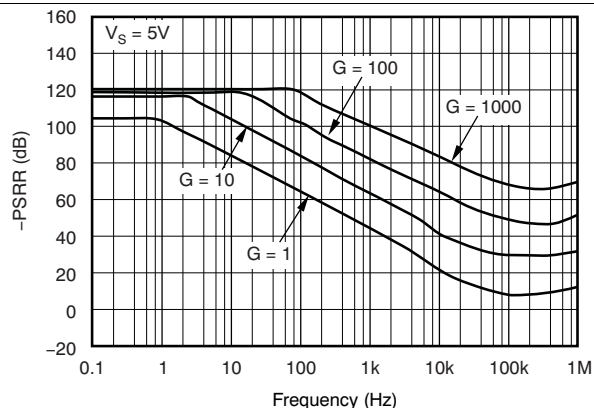
**Figure 23. Typical Common-Mode Range vs Output Voltage**



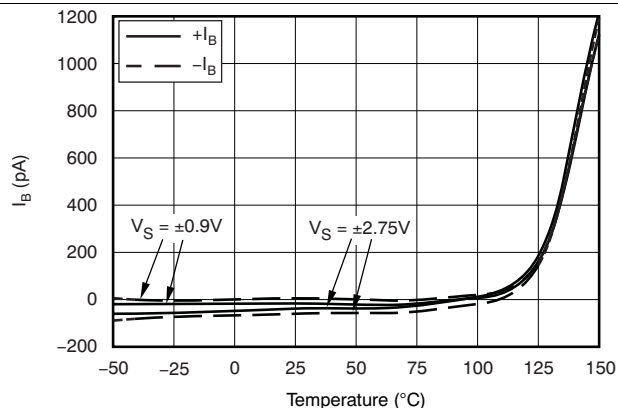
**Figure 24. Positive Power-Supply Rejection Ratio**

## Typical Characteristics (continued)

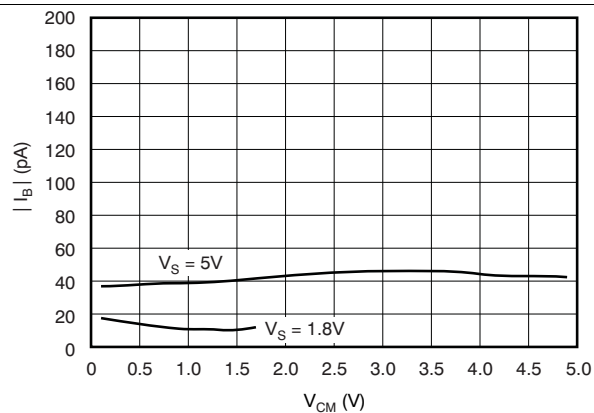
at  $T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{ V}$ ,  $R_L = 10\text{ k}\Omega$ ,  $V_{\text{REF}} = \text{mid supply}$ , and  $G = 1$  (unless otherwise noted)



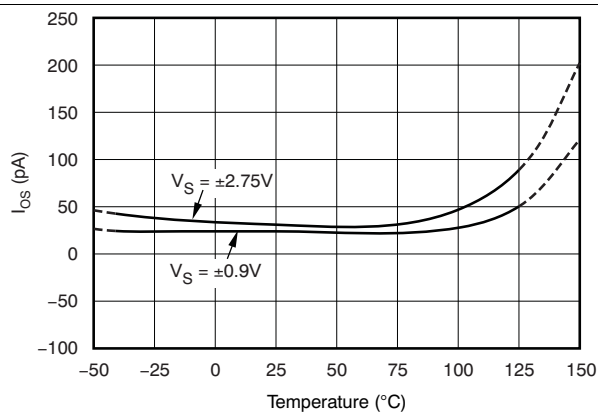
**Figure 25. Negative Power-Supply Rejection Ratio**



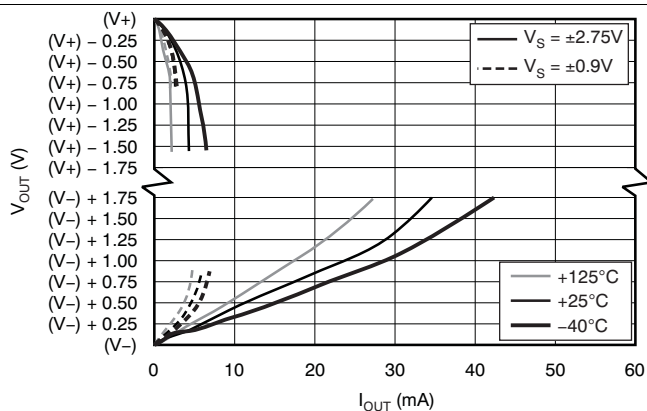
**Figure 26. Input Bias Current vs Temperature**



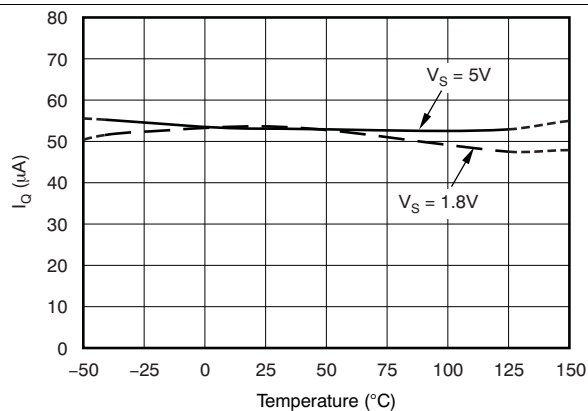
**Figure 27. Input Bias Current vs Common-Mode Voltage**



**Figure 28. Input Offset Current vs Temperature**



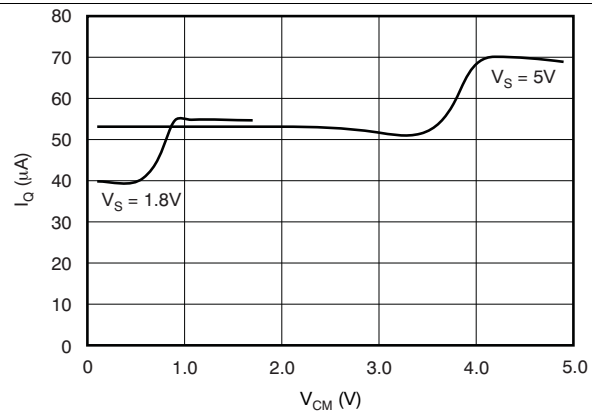
**Figure 29. Output Voltage Swing vs Output Current**



**Figure 30. Quiescent Current vs Temperature**

## Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{ V}$ ,  $R_L = 10\text{ k}\Omega$ ,  $V_{\text{REF}} = \text{midsupply}$ , and  $G = 1$  (unless otherwise noted)



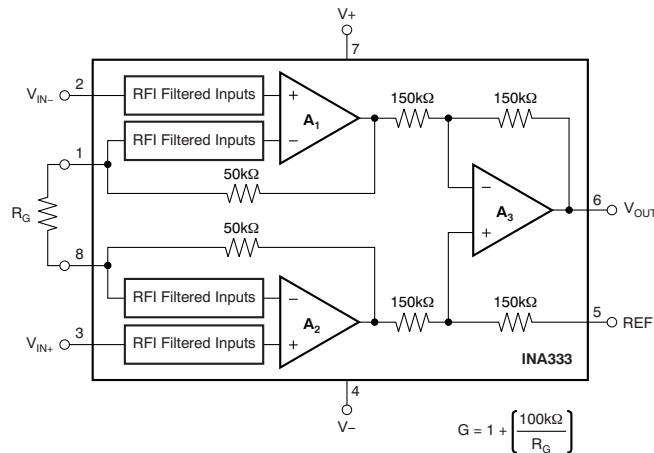
**Figure 31. Quiescent Current vs Common-Mode Voltage**

## 7 Detailed Description

### 7.1 Overview

The INA333 is a monolithic instrumentation amplifier (INA) based on the precision zero-drift OPA333 (operational amplifier) core. The INA333 also integrates laser-trimmed resistors to ensure excellent common-mode rejection and low gain error. The combination of the zero-drift amplifier core and the precision resistors allows this device to achieve outstanding DC precision and makes the INA333 ideal for many 3.3-V and 5-V industrial applications.

### 7.2 Functional Block Diagram



### 7.3 Feature Description

The INA333 is a low-power, zero-drift instrumentation amplifier offering excellent accuracy. The versatile three-operational-amplifier design and small size make the amplifiers ideal for a wide range of applications. Zero-drift chopper circuitry provides excellent DC specifications. A single external resistor sets any gain from 1 to 10,000. The INA333 is laser trimmed for very high common-mode rejection (100 dB at  $G \geq 100$ ). This device operates with power supplies as low as 1.8 V, and quiescent current of 50  $\mu$ A, typically.

### 7.4 Device Functional Modes

#### 7.4.1 Internal Offset Correction

INA333 internal operational amplifiers use an auto-calibration technique with a time-continuous 350-kHz operational amplifier in the signal path. The amplifier is zero-corrected every 8  $\mu$ s using a proprietary technique. Upon power up, the amplifier requires approximately 100  $\mu$ s to achieve specified VOS accuracy. This design has no aliasing or flicker noise.

#### 7.4.2 Input Common-Mode Range

The linear input voltage range of the input circuitry of the INA333 is from approximately 0.1 V below the positive supply voltage to 0.1 V above the negative supply. As a differential input voltage causes the output voltage to increase, however, the linear input range is limited by the output voltage swing of amplifiers A1 and A2. Thus, the linear common-mode input range is related to the output voltage of the complete amplifier. This behavior also depends on supply voltage—see Figure 20.

Input overload conditions can produce an output voltage that appears normal. For example, if an input overload condition drives both input amplifiers to the respective positive output swing limit, the difference voltage measured by the output amplifier is near zero. The output of the INA333 is near 0 V even though both inputs are overloaded.

## 8 Application and Implementation

### NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

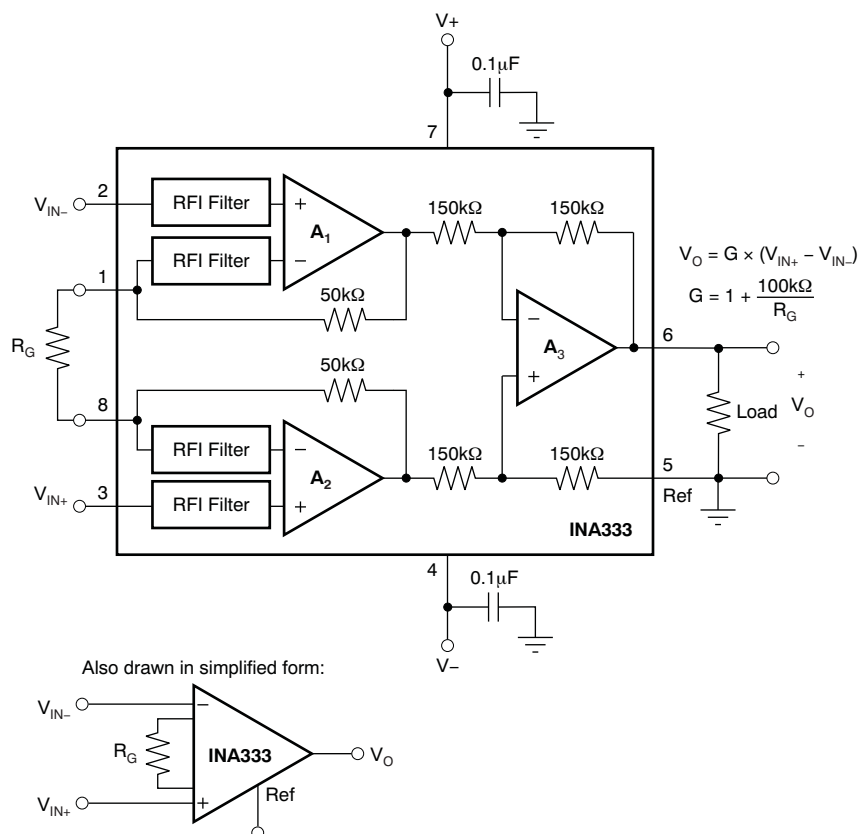
### 8.1 Application Information

The INA333 measures small differential voltage with high common-mode voltage developed between the noninverting and inverting input. The high input impedance makes the INA333 suitable for a wide range of applications. The ability to set the reference pin to adjust the functionality of the output signal offers additional flexibility that is practical for multiple configurations.

### 8.2 Typical Application

Figure 32 shows the basic connections required for operation of the INA333 device. Good layout practice mandates the use of bypass capacitors placed close to the device pins as shown.

The output of the INA333 device is referred to the output reference (REF) pin, which is normally grounded. This connection must be low-impedance to assure good common-mode rejection. Although 15  $\Omega$  or less of stray resistance can be tolerated while maintaining specified CMRR, small stray resistances of tens of  $\Omega$ s in series with the REF pin can cause noticeable degradation in CMRR.



**Figure 32. Basic Connections**

## Typical Application (continued)

### 8.2.1 Design Requirements

The device can be configured to monitor the input differential voltage when the gain of the input signal is set by the external resistor  $R_G$ . The output signal references to the Ref pin. The most common application is where the output is referenced to ground when no input signal is present by connecting the Ref pin to ground. When the input signal increases, the output voltage at the OUT pin increases, too.

### 8.2.2 Detailed Design Procedure

#### 8.2.2.1 Setting the Gain

Gain of the INA333 device is set by a single external resistor,  $R_G$ , connected between pins 1 and 8. The value of  $R_G$  is selected according to [Equation 1](#):

$$G = 1 + (100 \text{ k}\Omega / R_G) \quad (1)$$

[Table 1](#) lists several commonly-used gains and resistor values. The 100 k $\Omega$  in [Equation 1](#) comes from the sum of the two internal feedback resistors of  $A_1$  and  $A_2$ . These on-chip resistors are laser trimmed to accurate absolute values. The accuracy and temperature coefficient of these resistors are included in the gain accuracy and drift specifications of the INA333 device.

The stability and temperature drift of the external gain setting resistor,  $R_G$ , also affects gain. The contribution of  $R_G$  to gain accuracy and drift can be directly inferred from the gain [Equation 1](#). Low resistor values required for high gain can make wiring resistance important. Sockets add to the wiring resistance and contribute additional gain error (possibly an unstable gain error) in gains of approximately 100 or greater. To ensure stability, avoid parasitic capacitance of more than a few picofarads at the  $R_G$  connections. Careful matching of any parasitics on both  $R_G$  pins maintains optimal CMRR over frequency.

**Table 1. Commonly-Used Gains and Resistor Values**

| DESIRED GAIN | $R_G$ ( $\Omega$ ) | NEAREST 1% $R_G$ ( $\Omega$ ) |
|--------------|--------------------|-------------------------------|
| 1            | NC <sup>(1)</sup>  | NC                            |
| 2            | 100k               | 100k                          |
| 5            | 25k                | 24.9k                         |
| 10           | 11.1k              | 11k                           |
| 20           | 5.26k              | 5.23k                         |
| 50           | 2.04k              | 2.05                          |
| 100          | 1.01k              | 1k                            |
| 200          | 502.5              | 499                           |
| 500          | 200.4              | 200                           |
| 1000         | 100.1              | 100                           |

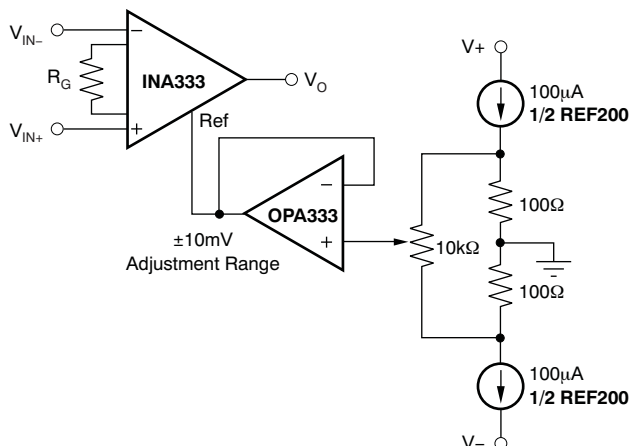
(1) NC denotes no connection. When using the SPICE model, the simulation will not converge unless a resistor is connected to the  $R_G$  pins; use a very large resistor value.

#### 8.2.2.2 Internal Offset Correction

The INA333 device internal operational amplifiers use an auto-calibration technique with a time-continuous 350-kHz operational amplifier in the signal path. The amplifier is zero-corrected every 8  $\mu$ s using a proprietary technique. Upon power-up, the amplifier requires approximately 100  $\mu$ s to achieve specified  $V_{OS}$  accuracy. This design has no aliasing or flicker noise.

#### 8.2.2.3 Offset Trimming

Most applications require no external offset adjustment; however, if necessary, adjustments can be made by applying a voltage to the REF pin. [Figure 33](#) shows an optional circuit for trimming the output offset voltage. The voltage applied to REF pin is summed at the output. The operational amplifier buffer provides low impedance at the REF pin to preserve good common-mode rejection.



**Figure 33. Optional Trimming of Output Offset Voltage**

#### 8.2.2.4 Noise Performance

The auto-calibration technique used by the INA333 device results in reduced low frequency noise, typically only 50 nV/√Hz, (G = 100). The spectral noise density can be seen in detail in [Figure 8](#). Low frequency noise of the INA333 device is approximately 1 μV<sub>PP</sub> measured from 0.1 Hz to 10 Hz, (G = 100).

#### 8.2.2.5 Input Bias Current Return Path

The input impedance of the INA333 device is extremely high—approximately 100 GΩ. However, a path must be provided for the input bias current of both inputs. This input bias current is typically ±70 pA. High input impedance means that this input bias current changes very little with varying input voltage.

Input circuitry must provide a path for this input bias current for proper operation. [Figure 34](#) shows various provisions for an input bias current path. Without a bias current path, the inputs float to a potential that exceeds the common-mode range of the INA333 device, and the input amplifiers will saturate. If the differential source resistance is low, the bias current return path can be connected to one input (see the thermocouple example in [Figure 34](#)). With higher source impedance, using two equal resistors provides a balanced input with possible advantages of lower input offset voltage as a result of bias current and better high-frequency common-mode rejection.

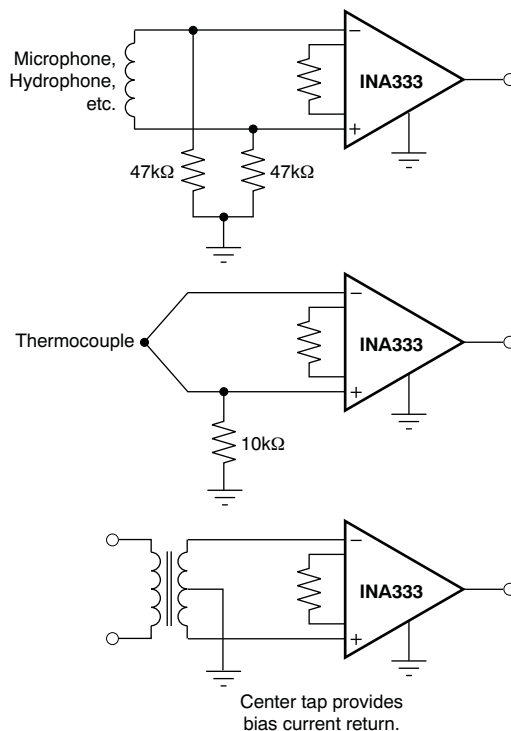


Figure 34. Providing an Input Common-Mode Current Path

#### 8.2.2.6 Input Common-Mode Range

The linear input voltage range of the input circuitry of the INA333 device is from approximately 0.1 V below the positive supply voltage to 0.1 V above the negative supply. As a differential input voltage causes the output voltage to increase, however, the linear input range is limited by the output voltage swing of amplifiers A<sub>1</sub> and A<sub>2</sub>. Thus, the linear common-mode input range is related to the output voltage of the complete amplifier. This behavior also depends on supply voltage—see Figure 20 to Figure 23 in the [Typical Characteristics](#) section.

Input overload conditions can produce an output voltage that appears normal. For example, if an input overload condition drives both input amplifiers to the respective positive output swing limit, the difference voltage measured by the output amplifier is near zero. The output of the INA333 is near 0 V even though both inputs are overloaded.

#### 8.2.2.7 Operating Voltage

The INA333 operates over a power-supply range of 1.8 V to 5.5 V (±0.9 V to ±2.75 V). Supply voltages higher than 7 V (absolute maximum) can permanently damage the device. Parameters that vary over supply voltage or temperature are shown in the [Typical Characteristics](#) section of this data sheet.

#### 8.2.2.8 Low Voltage Operation

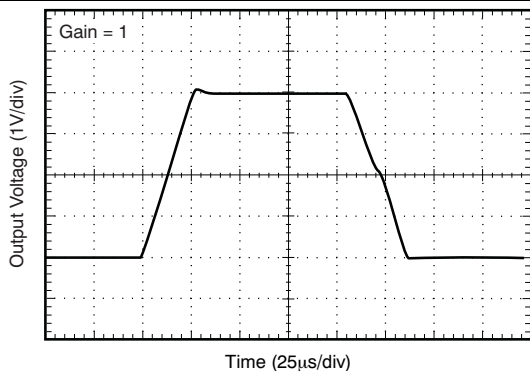
The INA333 device can be operated on power supplies as low as ±0.9 V. Most parameters vary only slightly throughout this supply voltage range—see the [Typical Characteristics](#) section. Operation at very low supply voltage requires careful attention to assure that the input voltages remain within the linear range. Voltage swing requirements of internal nodes limit the input common-mode range with low power-supply voltage. [Figure 20](#) to [Figure 23](#) show the range of linear operation for various supply voltages and gains.

#### 8.2.2.9 Single-Supply Operation

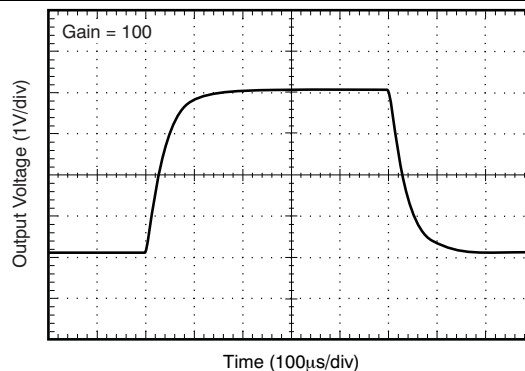
The INA333 device can be used on single power supplies of 1.8 V to 5.5 V. [Figure 35](#) shows a basic single-supply circuit. The output REF pin is connected to mid-supply. Zero differential input voltage demands an output voltage of mid-supply. Actual output voltage swing is limited to approximately 50 mV more than ground, when the load is referred to ground as shown. [Figure 29](#) shows how the output voltage swing varies with output current.



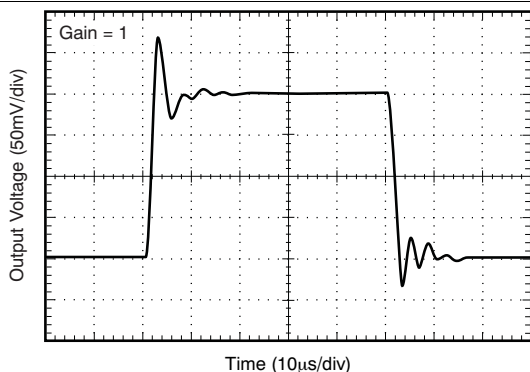
## 8.2.3 Application Curves



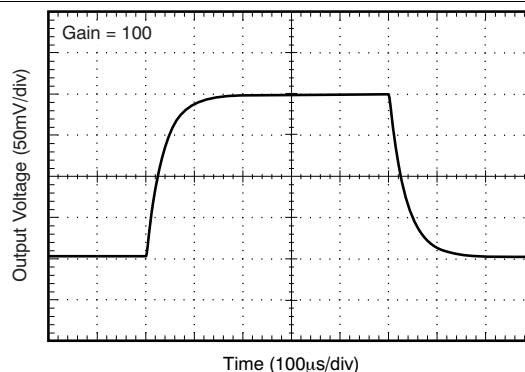
**Figure 36. Large Signal Response**



**Figure 37. Large-Signal Step Response**



**Figure 38. Small-Signal Step Response**



**Figure 39. Small-Signal Step Response**

## 9 Power Supply Recommendations

The minimum power supply voltage for INA333 is 1.8 V and the maximum power supply voltage is 5.5 V. For optimum performance, 3.3 V to 5 V is recommended. TI recommends adding a bypass capacitor at the input to compensate for the layout and power supply source impedance.

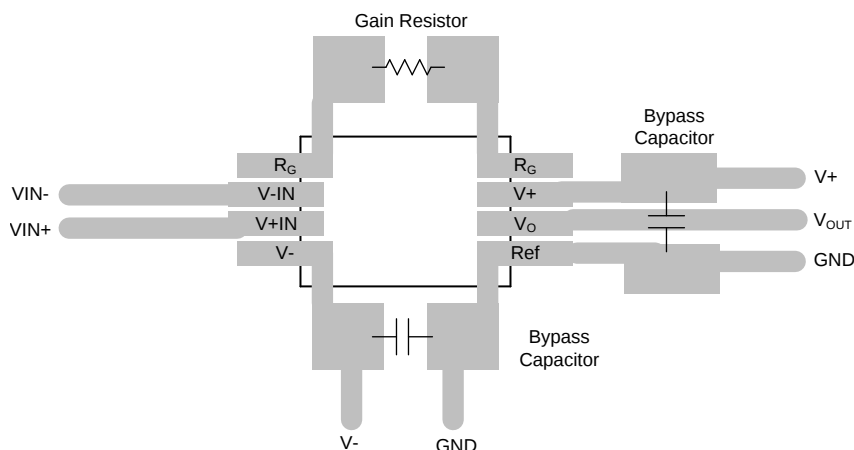
## 10 Layout

### 10.1 Layout Guidelines

Attention to good layout practices is always recommended. Keep traces short and, when possible, use a printed-circuit-board (PCB) ground plane with surface-mount components placed as close to the device pins as possible. Place a 0.1- $\mu$ F bypass capacitor closely across the supply pins. These guidelines should be applied throughout the analog circuit to improve performance and provide benefits such as reducing the electromagnetic-interference (EMI) susceptibility.

Instrumentation amplifiers vary in the susceptibility to radio-frequency interference (RFI). RFI can generally be identified as a variation in offset voltage or DC signal levels with changes in the interfering RF signal. The INA333 device has been specifically designed to minimize susceptibility to RFI by incorporating passive RC filters with an 8-MHz corner frequency at the  $V_{IN+}$  and  $V_{IN-}$  inputs. As a result, the INA333 device demonstrates remarkably low sensitivity compared to previous generation devices. Strong RF fields may continue to cause varying offset levels, however, and may require additional shielding.

### 10.2 Layout Example



**Figure 40. INA333 Layout**

## 11 器件和文档支持

### 11.1 器件支持

#### 11.1.1 开发支持

##### 11.1.1.1 TINA-TI (免费下载软件)

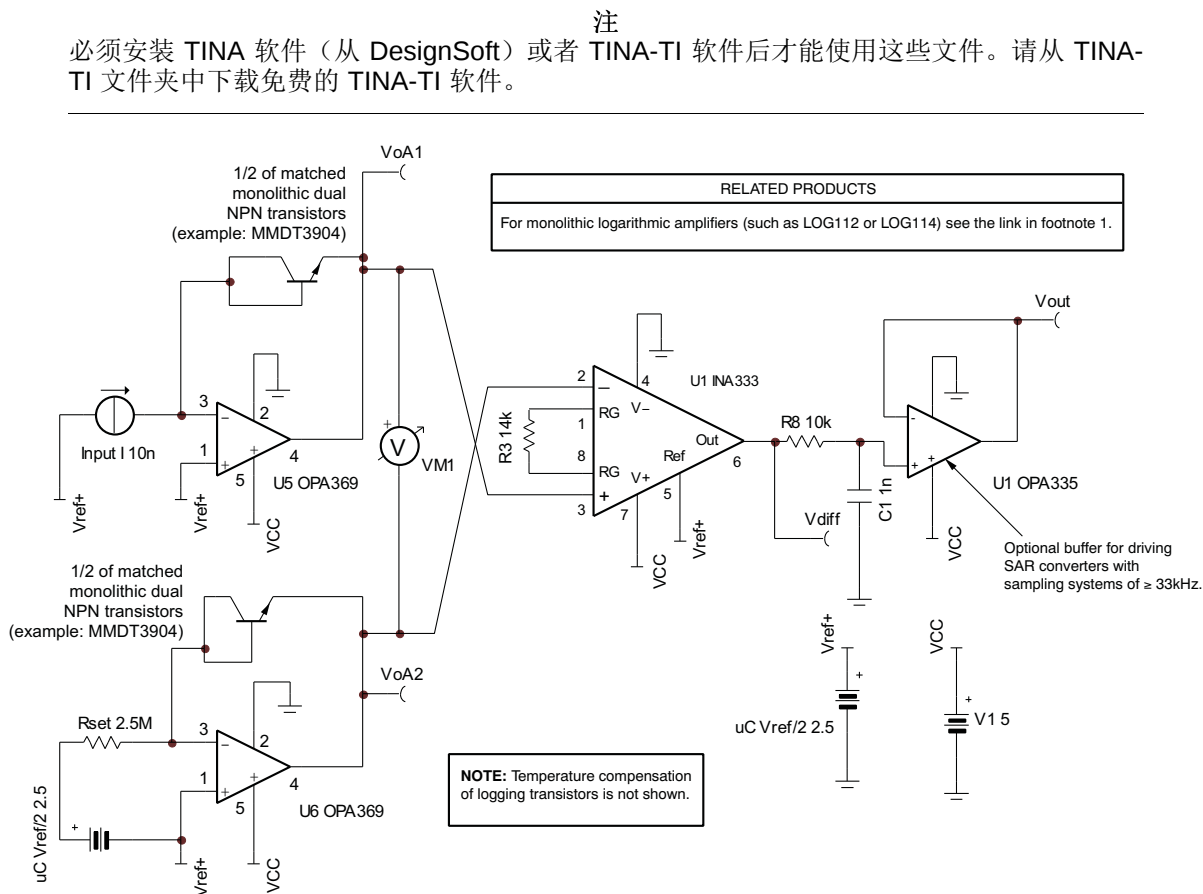
##### TINA-TI 基于 SPICE 的模拟仿真程序 (适用于 INA333)

TINA 是一款简单、功能强大且易于使用的电路仿真程序，此程序基于 SPICE 引擎。TINA-TI 是 TINA 软件的一款免费全功能版本，除了一系列无源和有源模型外，此版本软件还预先载入了一个宏模型库。它提供所有传统的 SPICE 直流 (DC)、瞬态和频域分析以及其他设计功能。

TINA-TI 可从 [Analog eLab Design Center \(模拟电子实验室设计中心\)](#) 免费下载，它提供全面的后续处理能力，使得用户能够以多种方式形成结果。

虚拟仪器为用户提供选择输入波形和探测电路节点、电压和波形的功能，从而创建一个动态的快速入门工具。

图 41 和图 42 给出了适用于 INA333 器件的 TINA-TI 电路示例，这些电路可用于开发、修改和评估特定用途的电路设计。下面给出了这些仿真文件的下载链接。



(1) 如下链接会打开 TI 对数放大器网页：对数放大器产品主页

图 41. 便携式电池供电类系统的低功耗对数函数电路 (例如血糖仪)

要下载包含此电路 TINA-TI 仿真文件的压缩文件，请点击如下链接：[对数电路](#)。



## 11.5 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 12 机械、封装和可订购信息

以下页中包括机械、封装和可订购信息。这些信息是针对指定器件可提供的最新数据。这些数据会在无通知且不对本文档进行修订的情况下发生改变。欲获得该数据表的浏览器版本，请查阅左侧的导航栏。

## 重要声明

德州仪器(TI) 及其下属子公司有权根据 JESD46 最新标准, 对所提供的产品和服务进行更正、修改、增强、改进或其它更改, 并有权根据 JESD48 最新标准中止提供任何产品和服务。客户在下订单前应获取最新的相关信息, 并验证这些信息是否完整且是最新的。所有产品的销售都遵循在订单确认时所提供的TI 销售条款与条件。

TI 保证其所销售的组件的性能符合产品销售时 TI 半导体产品销售条件与条款的适用规范。仅在 TI 保证的范围内, 且 TI 认为 有必要时才会使用测试或其它质量控制技术。除非适用法律做出了硬性规定, 否则没有必要对每种组件的所有参数进行测试。

TI 对应用帮助或客户产品设计不承担任何义务。客户应对其使用 TI 组件的产品和应用自行负责。为尽量减小与客户产品和应用相关的风险, 客户应提供充分的设计与操作安全措施。

TI 不对任何 TI 专利权、版权、屏蔽作品权或其它与使用了 TI 组件或服务的组合设备、机器或流程相关的 TI 知识产权中授予 的直接或隐含权限作出任何保证或解释。TI 所发布的与第三方产品或服务有关的信息, 不能构成从 TI 获得使用这些产品或服务 的许可、授权、或认可。使用此类信息可能需要获得第三方的专利权或其它知识产权方面的许可, 或是 TI 的专利权或其它 知识产权方面的许可。

对于 TI 的产品手册或数据表中 TI 信息的重要部分, 仅在没有对内容进行任何篡改且带有相关授权、条件、限制和声明的情况 下才允许进行复制。TI 对此类篡改过的文件不承担任何责任或义务。复制第三方的信息可能需要服从额外的限制条件。

在转售 TI 组件或服务时, 如果对该组件或服务参数的陈述与 TI 标明的参数相比存在差异或虚假成分, 则会失去相关 TI 组件 或服务的所有明示或暗示授权, 且这是不正当的、欺诈性商业行为。TI 对任何此类虚假陈述均不承担任何责任或义务。

客户认可并同意, 尽管任何应用相关信息或支持仍可能由 TI 提供, 但他们将独力负责满足与其产品及其应用中使用的 TI 产品 相关的所有法律、法规和安全相关要求。客户声明并同意, 他们具备制定与实施安全措施所需的全部专业技术和知识, 可预见 故障的危险后果、监测故障及其后果、降低有可能造成人身伤害的故障的发生机率并采取适当的补救措施。客户将全额赔偿因 在此类安全关键应用中使用任何 TI 组件而对 TI 及其代理造成的任何损失。

在某些场合中, 为了推进安全相关应用有可能对 TI 组件进行特别的促销。TI 的目标是利用此类组件帮助客户设计和创立其特 有的可满足适用的功能安全性标准和要求的终端产品解决方案。尽管如此, 此类组件仍然服从这些条款。

TI 组件未获得用于 FDA Class III (或类似的生命攸关医疗设备) 的授权许可, 除非各方授权官员已经达成了专门管控此类使 用的特别协议。

只有那些 TI 特别注明属于军用等级或“增强型塑料”的 TI 组件才是设计或专门用于军事/航空应用或环境的。购买者认可并同 意, 对并非指定面向军事或航空航天用途的 TI 组件进行军事或航空航天方面的应用, 其风险由客户单独承担, 并且由客户独 力负责满足与此类使用相关的所有法律和法规要求。

TI 已明确指定符合 ISO/TS16949 要求的产品, 这些产品主要用于汽车。在任何情况下, 因使用非指定产品而无法达到 ISO/TS16949 要求, TI 不承担任何责任。

|               | 产品                                                                                         |              | 应用                                                                           |
|---------------|--------------------------------------------------------------------------------------------|--------------|------------------------------------------------------------------------------|
| 数字音频          | <a href="http://www.ti.com.cn/audio">www.ti.com.cn/audio</a>                               | 通信与电信        | <a href="http://www.ti.com.cn/telecom">www.ti.com.cn/telecom</a>             |
| 放大器和线性器件      | <a href="http://www.ti.com.cn/amplifiers">www.ti.com.cn/amplifiers</a>                     | 计算机及周边       | <a href="http://www.ti.com.cn/computer">www.ti.com.cn/computer</a>           |
| 数据转换器         | <a href="http://www.ti.com.cn/dataconverters">www.ti.com.cn/dataconverters</a>             | 消费电子         | <a href="http://www.ti.com.cn/consumer-apps">www.ti.com.cn/consumer-apps</a> |
| DLP® 产品       | <a href="http://www.dlp.com">www.dlp.com</a>                                               | 能源           | <a href="http://www.ti.com.cn/energy">www.ti.com.cn/energy</a>               |
| DSP - 数字信号处理器 | <a href="http://www.ti.com.cn/dsp">www.ti.com.cn/dsp</a>                                   | 工业应用         | <a href="http://www.ti.com.cn/industrial">www.ti.com.cn/industrial</a>       |
| 时钟和计时器        | <a href="http://www.ti.com.cn/clockandtimers">www.ti.com.cn/clockandtimers</a>             | 医疗电子         | <a href="http://www.ti.com.cn/medical">www.ti.com.cn/medical</a>             |
| 接口            | <a href="http://www.ti.com.cn/interface">www.ti.com.cn/interface</a>                       | 安防应用         | <a href="http://www.ti.com.cn/security">www.ti.com.cn/security</a>           |
| 逻辑            | <a href="http://www.ti.com.cn/logic">www.ti.com.cn/logic</a>                               | 汽车电子         | <a href="http://www.ti.com.cn/automotive">www.ti.com.cn/automotive</a>       |
| 电源管理          | <a href="http://www.ti.com.cn/power">www.ti.com.cn/power</a>                               | 视频和影像        | <a href="http://www.ti.com.cn/video">www.ti.com.cn/video</a>                 |
| 微控制器 (MCU)    | <a href="http://www.ti.com.cn/microcontrollers">www.ti.com.cn/microcontrollers</a>         |              |                                                                              |
| RFID 系统       | <a href="http://www.ti.com.cn/rfidsys">www.ti.com.cn/rfidsys</a>                           |              |                                                                              |
| OMAP应用处理器     | <a href="http://www.ti.com.cn/omap">www.ti.com.cn/omap</a>                                 |              |                                                                              |
| 无线连通性         | <a href="http://www.ti.com.cn/wirelessconnectivity">www.ti.com.cn/wirelessconnectivity</a> | 德州仪器在线技术支持社区 | <a href="http://www.deyisupport.com">www.deyisupport.com</a>                 |

邮寄地址: 上海市浦东新区世纪大道1568号, 中建大厦32楼邮政编码: 200122  
Copyright © 2016, 德州仪器半导体技术(上海)有限公司

## PACKAGING INFORMATION

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| INA333AIDGKR     | ACTIVE        | VSSOP        | DGK                | 8    | 2500           | RoHS & Green    | NIPDAU   NIPDAUAG                    | Level-2-260C-1 YEAR  | -40 to 125   | I333                    | <a href="#">Samples</a> |
| INA333AIDGKRG4   | ACTIVE        | VSSOP        | DGK                | 8    | 2500           | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 125   | I333                    | <a href="#">Samples</a> |
| INA333AIDGKT     | ACTIVE        | VSSOP        | DGK                | 8    | 250            | RoHS & Green    | NIPDAU   NIPDAUAG                    | Level-2-260C-1 YEAR  | -40 to 125   | I333                    | <a href="#">Samples</a> |
| INA333AIDGKTG4   | ACTIVE        | VSSOP        | DGK                | 8    | 250            | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 125   | I333                    | <a href="#">Samples</a> |
| INA333AIDRGR     | ACTIVE        | SON          | DRG                | 8    | 3000           | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 125   | I333A                   | <a href="#">Samples</a> |
| INA333AIDRGT     | ACTIVE        | SON          | DRG                | 8    | 250            | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 125   | I333A                   | <a href="#">Samples</a> |

(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.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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**


\*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 |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| INA333AIDGKR | VSSOP        | DGK             | 8    | 2500 | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| INA333AIDGKT | VSSOP        | DGK             | 8    | 250  | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| INA333AIDRGR | SON          | DRG             | 8    | 3000 | 330.0              | 12.4               | 3.3     | 3.3     | 1.1     | 8.0     | 12.0   | Q2            |
| INA333AIDRGT | SON          | DRG             | 8    | 250  | 180.0              | 12.4               | 3.3     | 3.3     | 1.1     | 8.0     | 12.0   | Q2            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| INA333AIDGKR | VSSOP        | DGK             | 8    | 2500 | 366.0       | 364.0      | 50.0        |
| INA333AIDGKT | VSSOP        | DGK             | 8    | 250  | 366.0       | 364.0      | 50.0        |
| INA333AIDRGR | SON          | DRG             | 8    | 3000 | 853.0       | 449.0      | 35.0        |
| INA333AIDRGT | SON          | DRG             | 8    | 250  | 210.0       | 185.0      | 35.0        |

DGK (S-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE

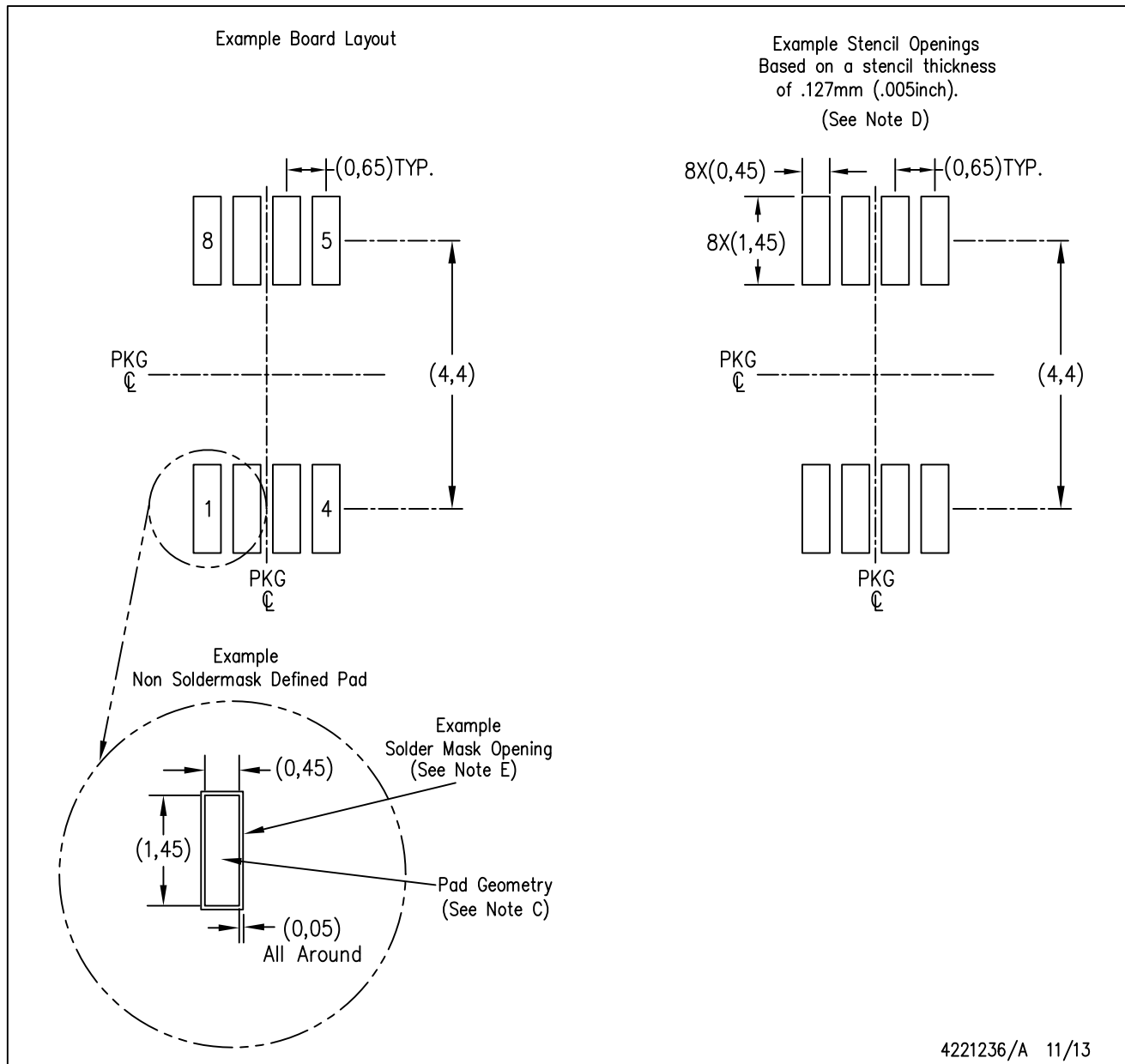


## NOTES:

- A. All linear dimensions are in 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 0.15 per end.
- D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
- E. Falls within JEDEC MO-187 variation AA, except interlead flash.

DGK (S-PDSO-G8)

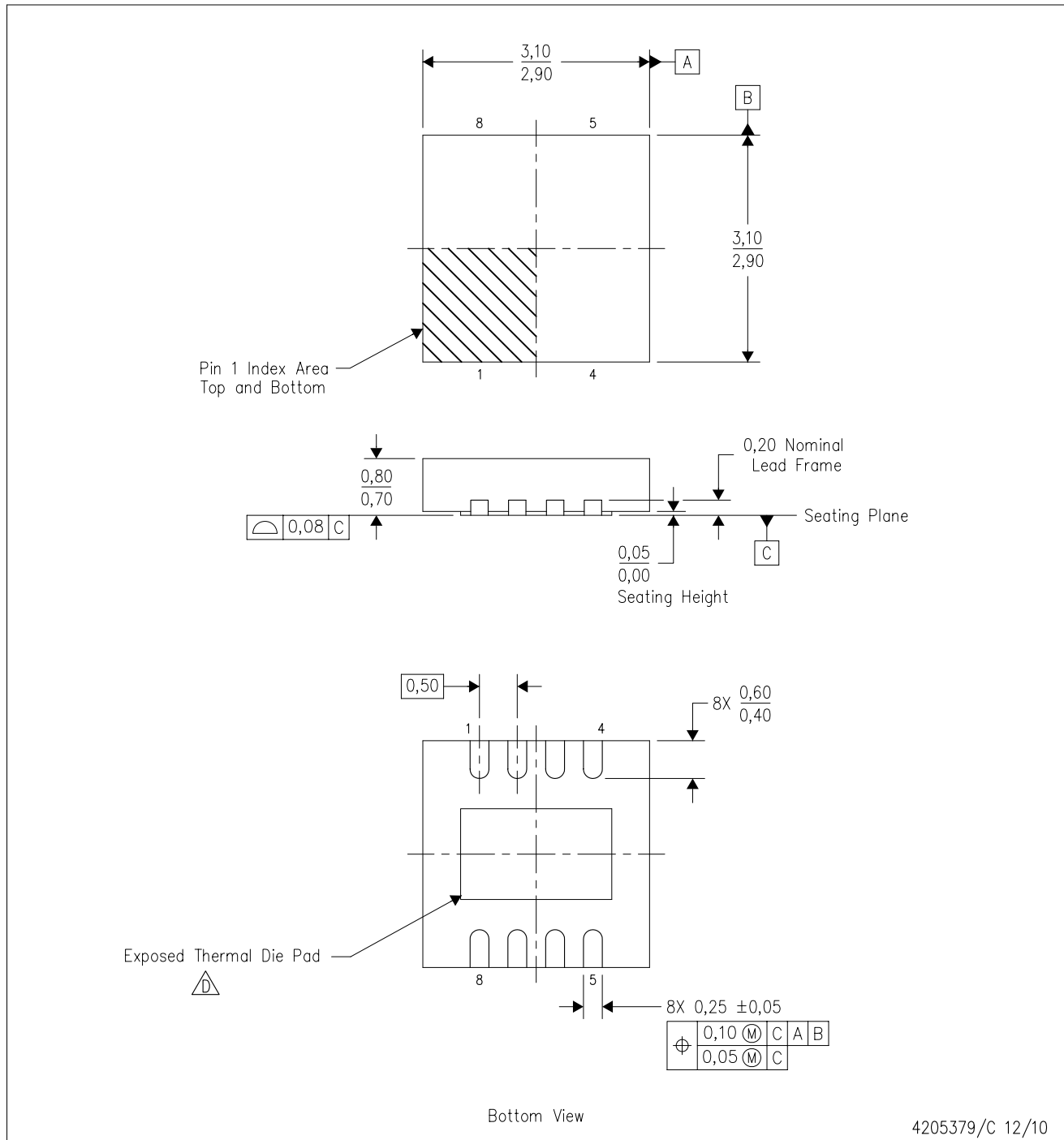
PLASTIC SMALL OUTLINE PACKAGE



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

DRG (S-PWSON-N8)

PLASTIC SMALL OUTLINE NO-LEAD

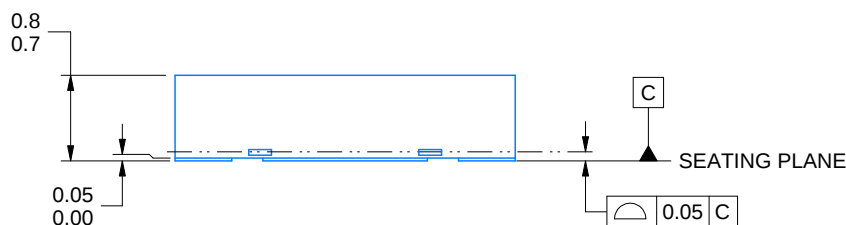


- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. SON (Small Outline No-Lead) package configuration.
  - D. The package thermal pad must be soldered to the board for thermal and mechanical performance. See the Product Data Sheet for details regarding the exposed thermal pad dimensions.
  - E. JEDEC MO-229 package registration pending.

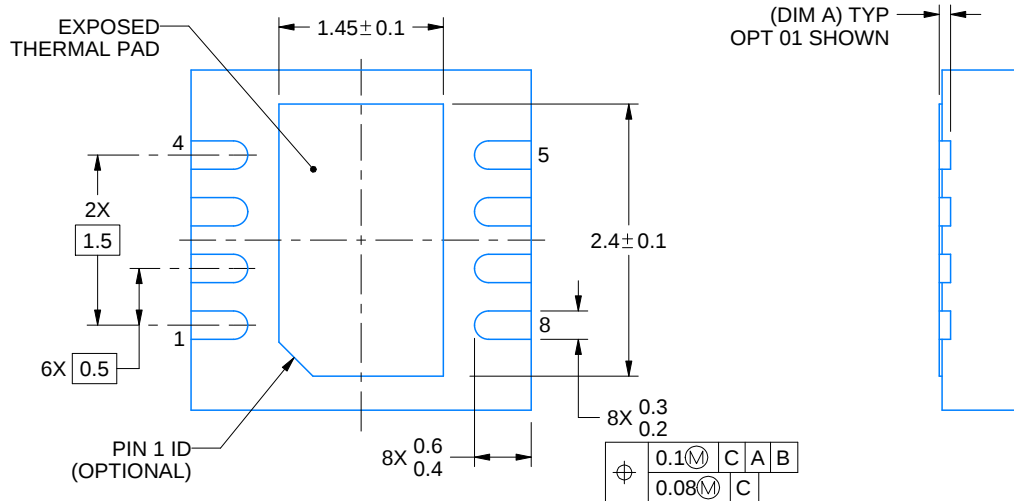


**WSON - 0.8 mm max height**

PLASTIC SMALL OUTLINE - NO LEAD



| DIMENSION A |       |
|-------------|-------|
| OPTION 01   | (0.1) |
| OPTION 02   | (0.2) |



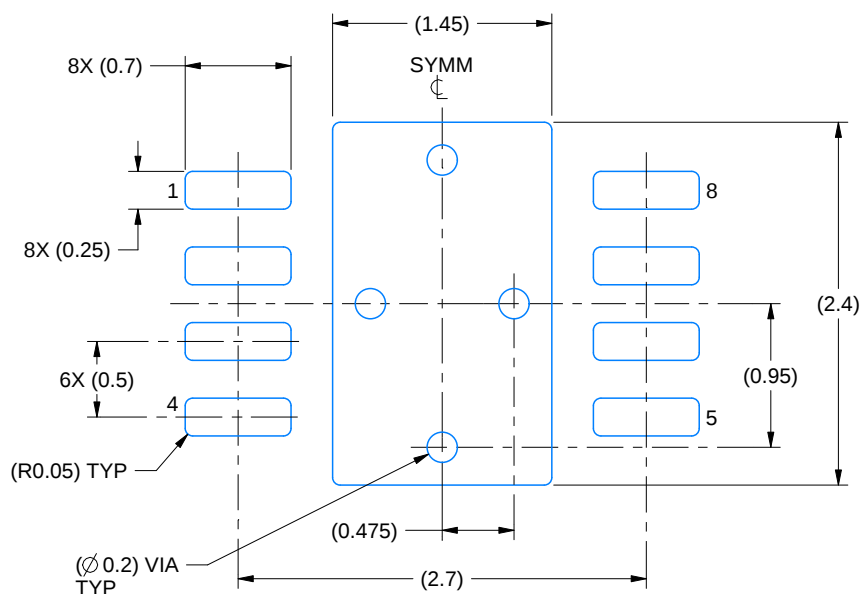
4218886/A 01/2020

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. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

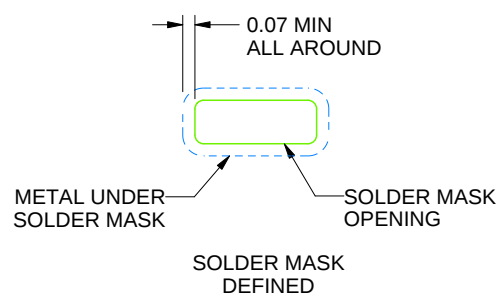
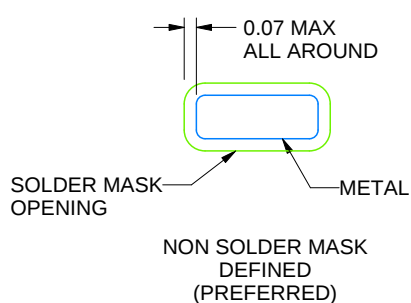
**DRG0008B**

**WSON - 0.8 mm max height**

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE  
SCALE:20X



## SOLDER MASK DETAILS

4218886/A 01/2020

NOTES: (continued)

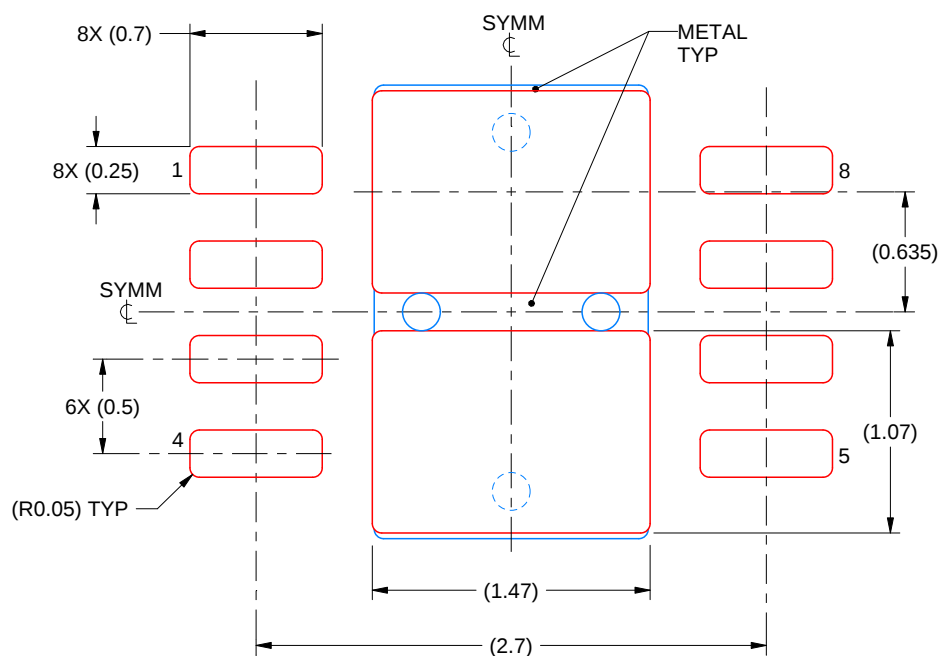
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slua271](http://www.ti.com/lit/slua271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

# EXAMPLE STENCIL DESIGN

DRG0008B

WSN - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD  
82% PRINTED SOLDER COVERAGE BY AREA  
SCALE:25X

4218886/A 01/2020

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

## 重要声明和免责声明

TI 均以“原样”提供技术性 & 可靠性数据（包括数据表）、设计资源（包括参考设计）、应用或其他设计建议、网络工具、安全信息和其他资源，不保证其中不含任何瑕疵，且不做任何明示或暗示的担保，包括但不限于对适销性、适合某特定用途或不侵犯任何第三方知识产权的暗示担保。

所述资源可供专业开发人员应用 TI 产品进行设计使用。您将对以下行为独自承担全部责任：(1) 针对您的应用选择合适的 TI 产品；(2) 设计、验证并测试您的应用；(3) 确保您的应用满足相应标准以及任何其他安全、安保或其他要求。所述资源如有变更，恕不另行通知。TI 对您使用所述资源的授权仅限于开发资源所涉及 TI 产品的相关应用。除此之外不得复制或展示所述资源，也不提供其它 TI 或任何第三方的知识产权授权许可。如因使用所述资源而产生任何索赔、赔偿、成本、损失及债务等，TI 对此概不负责，并且您须赔偿由此对 TI 及其代表造成的损害。

TI 所提供产品均受 TI 的销售条款 (<http://www.ti.com.cn/zh-cn/legal/termsofsale.html>) 以及 [ti.com.cn](http://www.ti.com.cn) 上或随附 TI 产品提供的其他可适用条款的约束。TI 提供所述资源并不扩展或以其他方式更改 TI 针对 TI 产品所发布的可适用的担保范围或担保免责声明。

邮寄地址：上海市浦东新区世纪大道 1568 号中建大厦 32 楼，邮政编码：200122  
Copyright © 2020 德州仪器半导体技术（上海）有限公司