

## INA19x 共模电压范围为 -16V 至 +80V 的分流监测计

### 1 特性

- 宽共模电压范围：  
-16V 至 +80V
- 低误差：3.0%（整个温度范围内的最大值）
- 带宽：高达 500kHz
- 三种传递函数：20V/V、50V/V 和 100V/V
- 静态电流：900 $\mu$ A（最大值）
- 完整的电流感测解决方案

### 2 应用

- 焊接设备
- 笔记本电脑
- 手机
- 电信设备
- 汽车用
- 电源管理
- 电池充电器

### 3 说明

INA193–INA198 系列是电压输出分流监测计，能够在 -16V 至 +80V 范围内的共模电压下感测分流器两端的压降，与 INA19x 电源电压无关。这些器件均提供三种输出电压级别：20V/V、50V/V 和 100V/V。500kHz 带宽方便用于电流控制回路。INA193–INA195 器件与 INA196–INA198 器件的功能相同，但引脚配置有所不同。

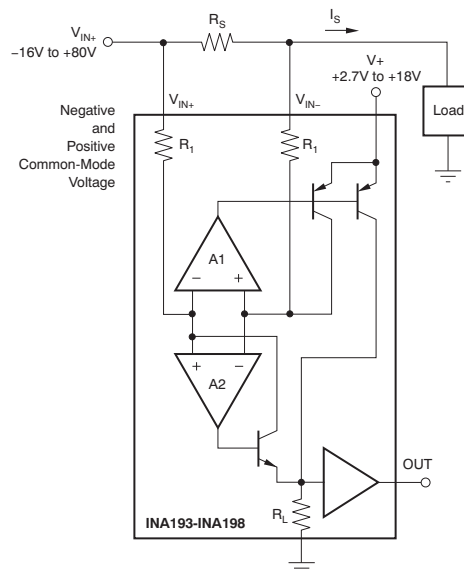
INA193-INA198 器件由 2.7V 至 18V 的单电源供电，最大供电电流为 900 $\mu$ A。这些器件均在 -40°C 至 +125°C 的扩展运行温度范围内额定运行，并且采用节省空间的 SOT-23 封装。

器件信息<sup>(1)</sup>

| 器件型号   | 封装         | 封装尺寸（标称值）       |
|--------|------------|-----------------|
| INA193 | SOT-23 (5) | 2.90mm x 1.60mm |
| INA194 |            |                 |
| INA195 |            |                 |
| INA196 |            |                 |
| INA197 |            |                 |
| INA198 |            |                 |

(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。

### LP38690 的



## 目录

|                                                |           |                                               |           |
|------------------------------------------------|-----------|-----------------------------------------------|-----------|
| 1 特性 .....                                     | 1         | 8.3 Feature Description .....                 | 12        |
| 2 应用 .....                                     | 1         | 8.4 Device Functional Modes .....             | 16        |
| 3 说明 .....                                     | 1         | <b>9 Application and Implementation</b> ..... | <b>22</b> |
| 4 修订历史记录 .....                                 | 2         | 9.1 Application Information .....             | 22        |
| 5 <b>Device Comparison Table</b> .....         | <b>3</b>  | 9.2 Typical Application .....                 | 22        |
| 6 <b>Pin Configuration and Functions</b> ..... | <b>3</b>  | <b>10 Power Supply Recommendations</b> .....  | <b>23</b> |
| 7 <b>Specifications</b> .....                  | <b>4</b>  | <b>11 Layout</b> .....                        | <b>23</b> |
| 7.1 Absolute Maximum Ratings .....             | 4         | 11.1 Layout Guidelines .....                  | 23        |
| 7.2 ESD Ratings .....                          | 4         | 11.2 Layout Example .....                     | 24        |
| 7.3 Recommended Operating Conditions .....     | 4         | <b>12 器件和文档支持</b> .....                       | <b>25</b> |
| 7.4 Thermal Information .....                  | 4         | 12.1 相关链接 .....                               | 25        |
| 7.5 Electrical Characteristics .....           | 5         | 12.2 商标 .....                                 | 25        |
| 7.6 Typical Characteristics .....              | 7         | 12.3 静电放电警告 .....                             | 25        |
| <b>8 Detailed Description</b> .....            | <b>11</b> | 12.4 Glossary .....                           | 25        |
| 8.1 Overview .....                             | 11        | <b>13 机械、封装和可订购信息</b> .....                   | <b>25</b> |
| 8.2 Functional Block Diagram .....             | 11        |                                               |           |

## 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 F (February 2010) to Revision G                                                                                                                                                                                                                                                                                                | Page |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| • Added <i>ESD Ratings</i> table, <i>Feature Description</i> section, <i>Device Functional Modes</i> , <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section ..... | 4    |

| Changes from Revision E (August 2006) to Revision F                                                                      | Page |
|--------------------------------------------------------------------------------------------------------------------------|------|
| • 已按照最新标准更新了文档格式 .....                                                                                                   | 1    |
| • Added test conditions to Output, <i>Total Output Error</i> parameter in Electrical Characteristics: $V_S = +12V$ ..... | 5    |

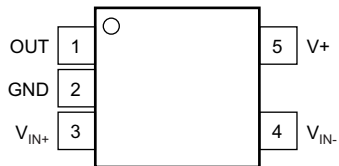
## 5 Device Comparison Table

| PART NUMBER | GAIN    | PINOUT <sup>(1)</sup> |
|-------------|---------|-----------------------|
| INA193      | 20 V/V  | Pinout #1             |
| INA194      | 50 V/V  | Pinout #1             |
| INA195      | 100 V/V | Pinout #1             |
| INA196      | 20 V/V  | Pinout #2             |
| INA197      | 50 V/V  | Pinout #2             |
| INA198      | 100 V/V | Pinout #2             |

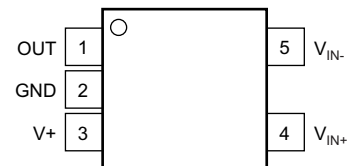
(1) See [Pin Configuration and Functions](#) for Pinout #1 and Pinout #2.

## 6 Pin Configuration and Functions

**DBV Package  
5-Pin SOT-23  
INA193, INA194, INA195 Top View**



**DBV Package  
5-Pin SOT-23  
INA196, INA197, INA198 Top View**



### Pin Functions

| NAME             | PIN                          |                              | TYPE   | DESCRIPTION                              |
|------------------|------------------------------|------------------------------|--------|------------------------------------------|
|                  | INA193,<br>INA194,<br>INA195 | INA196,<br>INA197,<br>INA198 |        |                                          |
|                  | DBV                          | DBV                          |        |                                          |
| GND              | 2                            | 2                            | GND    | Ground                                   |
| OUT              | 1                            | 1                            | O      | Output voltage                           |
| V+               | 5                            | 3                            | Analog | Power supply, 2.7 V to 18 V              |
| V <sub>IN+</sub> | 3                            | 4                            | I      | Connect to supply side of shunt resistor |
| V <sub>IN-</sub> | 4                            | 5                            | I      | Connect to load side of shunt resistor   |

## 7 Specifications

### 7.1 Absolute Maximum Ratings

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

|                                            | MIN       | MAX        | UNIT |
|--------------------------------------------|-----------|------------|------|
| Supply Voltage                             |           | 18         | V    |
| Analog Inputs, $V_{IN+}$ , $V_{IN-}$       | -18       | 18         | V    |
| Differential ( $V_{IN+}$ ) – ( $V_{IN-}$ ) | -18       | 18         | V    |
| Common-Mode <sup>(2)</sup>                 | -16       | 80         | V    |
| Analog Output, $Out^{(2)}$                 | GND – 0.3 | (V+) + 0.3 | V    |
| Input Current Into Any Pin <sup>(2)</sup>  |           | 5          | mA   |
| Operating Temperature                      | -55       | 150        | °C   |
| Junction Temperature                       |           | 150        | °C   |
| Storage temperature, $T_{stg}$             | -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 voltage at any pin may exceed the voltage shown if the current at that pin is limited to 5mA.

### 7.2 ESD Ratings

|                                     |                                                                                          | VALUE | UNIT |
|-------------------------------------|------------------------------------------------------------------------------------------|-------|------|
| $V_{(ESD)}$ Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins <sup>(1)</sup>              | ±4000 | V    |
|                                     | Charged device model (CDM), per JEDEC specification JESD22-C101, all pins <sup>(2)</sup> | ±1000 |      |

- (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.

### 7.3 Recommended Operating Conditions

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

|          |                                | MIN | NOM | MAX | UNIT |
|----------|--------------------------------|-----|-----|-----|------|
| $V_{CM}$ | Common-mode input voltage      |     | 12  |     | V    |
| $V+$     | Operating supply voltage       |     | 12  |     | V    |
| $T_A$    | Operating free-air temperature | -40 |     | 125 | °C   |

### 7.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | INA19x       | UNIT |
|-------------------------------|----------------------------------------------|--------------|------|
|                               |                                              | DBV (SOT-23) |      |
|                               |                                              | 5 PINS       |      |
| $R_{\theta JA}$               | Junction-to-ambient thermal resistance       | 221.7        | °C/W |
| $R_{\theta JC(top)}$          | Junction-to-case (top) thermal resistance    | 144.7        |      |
| $R_{\theta JB}$               | Junction-to-board thermal resistance         | 49.7         |      |
| $\Psi_{JT}$                   | Junction-to-top characterization parameter   | 26.1         |      |
| $\Psi_{JB}$                   | Junction-to-board characterization parameter | 49.0         |      |

- (1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](#).

## 7.5 Electrical Characteristics

All specifications at  $T_A = 25^\circ\text{C}$ ,  $V_S = 12\text{ V}$ ,  $V_{IN+} = 12\text{ V}$ , and  $V_{SENSE} = 100\text{ mV}$ , unless otherwise noted.

| PARAMETER                                                           |                                          | TEST CONDITIONS                                                                           | T <sub>A</sub> = 25°C            |     |       | T <sub>A</sub> = -40°C to +125°C |                          |       | UNIT |     |
|---------------------------------------------------------------------|------------------------------------------|-------------------------------------------------------------------------------------------|----------------------------------|-----|-------|----------------------------------|--------------------------|-------|------|-----|
|                                                                     |                                          |                                                                                           | MIN                              | TYP | MAX   | MIN                              | TYP                      | MAX   |      |     |
| <b>INPUT</b>                                                        |                                          |                                                                                           |                                  |     |       |                                  |                          |       |      |     |
| V <sub>SENSE</sub>                                                  | Full-Scale Input Voltage                 | V <sub>SENSE</sub> = V <sub>IN+</sub> - V <sub>IN-</sub>                                  | 0.15 (V <sub>S</sub> - 0.2)/Gain |     |       | -16                              |                          |       | V    |     |
| V <sub>CM</sub>                                                     | Common-Mode Input Range                  |                                                                                           | 80                               |     |       | -16                              |                          |       | V    |     |
| CMR                                                                 | Common-Mode Rejection                    | V <sub>IN+</sub> = -16 V to 80 V                                                          | 80                               | 94  |       |                                  |                          | dB    |      |     |
|                                                                     | Common-Mode Rejection, Over Temperature  | V <sub>IN+</sub> = 12 V to 80 V                                                           |                                  |     |       | 100                              | 120                      | dB    |      |     |
| V <sub>OS</sub>                                                     | Offset Voltage, RTI                      |                                                                                           | ±0.5                             |     | 2     |                                  | mV                       |       |      |     |
|                                                                     | Offset Voltage, RTI Over Temperature     |                                                                                           |                                  |     |       | 0.5                              | 3                        | mV    |      |     |
| dV <sub>OS</sub> /dT                                                | Offset Voltage, RTI vs Temperature       |                                                                                           |                                  |     |       | 2.5                              |                          | μV/°C |      |     |
| PSR                                                                 | Offset Voltage, RTI vs Power Supply      | V <sub>S</sub> = 2.7 V to 18 V, V <sub>IN+</sub> = 18 V                                   |                                  |     |       | 5                                | 100                      | μV/V  |      |     |
| I <sub>B</sub>                                                      | Input Bias Current, V <sub>IN-</sub> pin |                                                                                           |                                  |     |       | ±8                               | ±16                      | μA    |      |     |
| <b>OUTPUT (V<sub>SENSE</sub> ≥ 20mV)</b>                            |                                          |                                                                                           |                                  |     |       |                                  |                          |       |      |     |
| G                                                                   | Gain                                     | INA193, INA196                                                                            | 20                               |     |       |                                  |                          |       | V/V  |     |
|                                                                     |                                          | INA194, INA197                                                                            | 50                               |     |       |                                  |                          |       | V/V  |     |
|                                                                     |                                          | INA195, INA198                                                                            | 100                              |     |       |                                  |                          |       | V/V  |     |
|                                                                     | Gain Error                               | V <sub>SENSE</sub> = 20 mV to 100 mV, T <sub>A</sub> = 25°C                               | ±0.2%                            |     | ±1%   |                                  |                          |       |      |     |
|                                                                     | Gain Error Over Temperature              | V <sub>SENSE</sub> = 20 mV to 100 mV                                                      |                                  |     |       | ±2                               |                          |       |      |     |
|                                                                     | Total Output Error <sup>(1)</sup>        | V <sub>SENSE</sub> = 100 mV                                                               | ±0.75%                           |     | ±2.2% |                                  |                          |       |      |     |
|                                                                     | Total Output Error Over Temperature      |                                                                                           |                                  |     |       | ±1%                              | ±3%                      |       |      |     |
|                                                                     | Nonlinearity Error                       | V <sub>SENSE</sub> = 20 mV to 100 mV                                                      | ±0.002%                          |     | ±0.1% |                                  |                          |       |      |     |
| R <sub>O</sub>                                                      | Output Impedance                         |                                                                                           | 1.5                              |     |       |                                  |                          |       | Ω    |     |
|                                                                     | Maximum Capacitive Load                  | No Sustained Oscillation                                                                  | 10                               |     |       |                                  |                          |       | nF   |     |
| Output <sup>(2)</sup>                                               | All Devices                              | -16 V ≤ V <sub>CM</sub> < 0 V, V <sub>SENSE</sub> < 20 mV                                 | 300                              |     |       |                                  |                          |       | mV   |     |
|                                                                     |                                          | V <sub>S</sub> < V <sub>CM</sub> ≤ 80 V, V <sub>SENSE</sub> < 20 mV                       | 300                              |     |       |                                  |                          |       | mV   |     |
|                                                                     | INA193, INA196                           | 0 V ≤ V <sub>CM</sub> ≤ V <sub>S</sub> , V <sub>S</sub> = 5 V, V <sub>SENSE</sub> < 20 mV |                                  |     |       | 0.4                              |                          | V     |      |     |
|                                                                     | INA194, INA197                           |                                                                                           |                                  |     |       | 1                                |                          | V     |      |     |
| INA195, INA198                                                      |                                          |                                                                                           |                                  | 2   |       | V                                |                          |       |      |     |
| <b>VOLTAGE OUTPUT<sup>(3)</sup> (R<sub>L</sub> = 100 kΩ to GND)</b> |                                          |                                                                                           |                                  |     |       |                                  |                          |       |      |     |
|                                                                     | Swing to V+ Power-Supply Rail            |                                                                                           |                                  |     |       | (V+) - 0.1                       | (V+) - 0.2               | V     |      |     |
|                                                                     | Swing to GND <sup>(4)</sup>              |                                                                                           |                                  |     |       | (V <sub>GND</sub> ) + 3          | (V <sub>GND</sub> ) + 50 | mV    |      |     |
| <b>FREQUENCY RESPONSE</b>                                           |                                          |                                                                                           |                                  |     |       |                                  |                          |       |      |     |
| BW                                                                  | Bandwidth                                | INA193, INA196                                                                            | C <sub>LOAD</sub> = 5 pF         | 500 |       |                                  |                          |       |      | kHz |
|                                                                     |                                          | INA194, INA197                                                                            |                                  | 300 |       |                                  |                          |       |      | kHz |
|                                                                     |                                          | INA195, INA198                                                                            |                                  | 200 |       |                                  |                          |       |      | kHz |

(1) Total output error includes effects of gain error and V<sub>OS</sub>.

(2) For details on this region of operation, see the *Accuracy Variations as a Result of V<sub>SENSE</sub> and Common-Mode Voltage* section.

(3) See Typical Characteristic curve *Output Swing vs Output Current*, Figure 7.

(4) Specified by design.

## Electrical Characteristics (continued)

All specifications at  $T_A = 25^\circ\text{C}$ ,  $V_S = 12\text{ V}$ ,  $V_{IN+} = 12\text{ V}$ , and  $V_{SENSE} = 100\text{ mV}$ , unless otherwise noted.

| PARAMETER                | TEST CONDITIONS                    | $T_A = 25^\circ\text{C}$  |     |     | $T_A = -40^\circ\text{C to } +125^\circ\text{C}$ |     |     | UNIT                   |
|--------------------------|------------------------------------|---------------------------|-----|-----|--------------------------------------------------|-----|-----|------------------------|
|                          |                                    | MIN                       | TYP | MAX | MIN                                              | TYP | MAX |                        |
| Phase Margin             | $C_{LOAD} < 10\text{ nF}$          |                           | 40  |     |                                                  |     |     |                        |
| SR                       | Slew Rate                          |                           | 1   |     |                                                  |     |     | V/ $\mu\text{s}$       |
| $t_S$                    | Settling Time (1%)                 |                           | 2   |     |                                                  |     |     | $\mu\text{s}$          |
| <b>NOISE, RTI</b>        |                                    |                           |     |     |                                                  |     |     |                        |
|                          | Voltage Noise Density              |                           | 40  |     |                                                  |     |     | nV/ $\sqrt{\text{Hz}}$ |
| <b>POWER SUPPLY</b>      |                                    |                           |     |     |                                                  |     |     |                        |
| $V_S$                    | Operating Range                    |                           |     |     | 2.7                                              |     | 18  | V                      |
| $I_Q$                    | Quiescent Current                  | $V_{OUT} = 2\text{ V}$    | 700 | 900 |                                                  |     |     | $\mu\text{A}$          |
|                          | Quiescent Current Over Temperature | $V_{SENSE} = 0\text{ mV}$ |     |     |                                                  | 370 | 950 | $\mu\text{A}$          |
| <b>TEMPERATURE RANGE</b> |                                    |                           |     |     |                                                  |     |     |                        |
|                          | Specified Temperature Range        |                           | -40 | 125 |                                                  |     |     | $^\circ\text{C}$       |
|                          | Operating Temperature Range        |                           | -55 | 150 |                                                  |     |     | $^\circ\text{C}$       |
|                          | Storage Temperature Range          |                           | -65 | 150 |                                                  |     |     | $^\circ\text{C}$       |
| $\theta_{JA}$            | Thermal Resistance, SOT23          |                           | 200 |     |                                                  |     |     | $^\circ\text{C/W}$     |

## 7.6 Typical Characteristics

All specifications at  $T_A = 25^\circ\text{C}$ ,  $V_S = 12\text{ V}$ , and  $V_{IN+} = 12\text{ V}$ , and  $V_{SENSE} = 100\text{ mV}$ , unless otherwise noted.

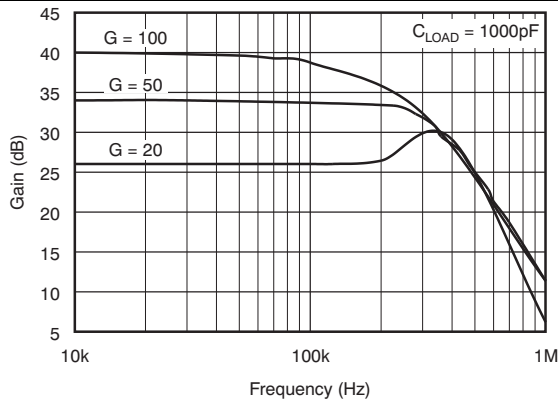


Figure 1. Gain vs Frequency

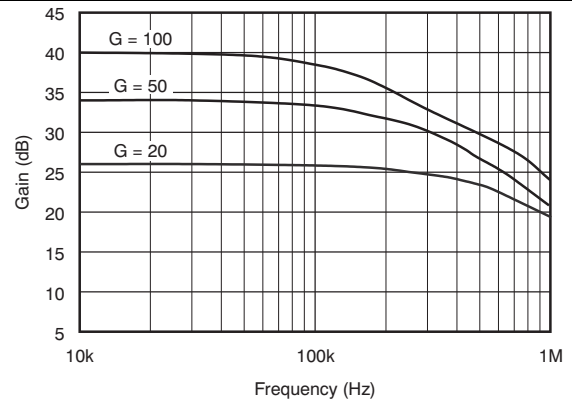


Figure 2. Gain vs Frequency

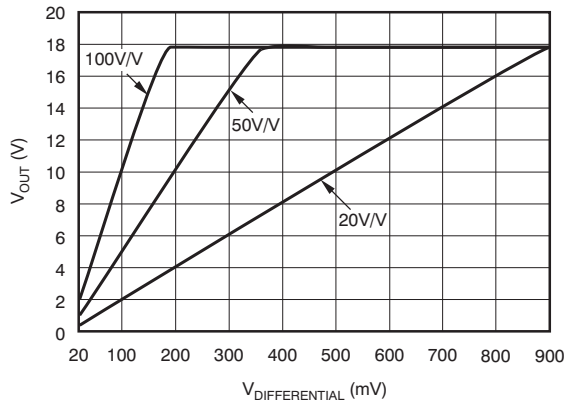


Figure 3. Gain Plot

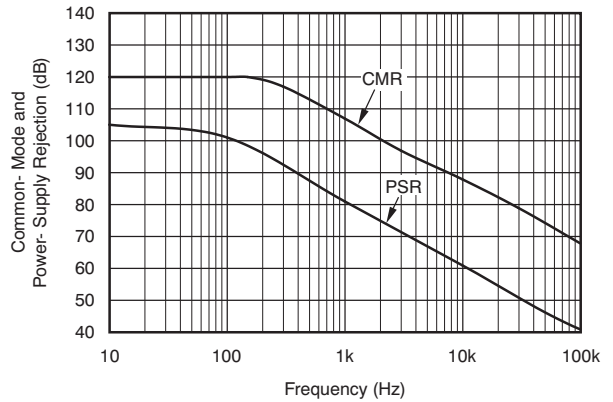


Figure 4. Common-Mode and Power-Supply Rejection vs Frequency

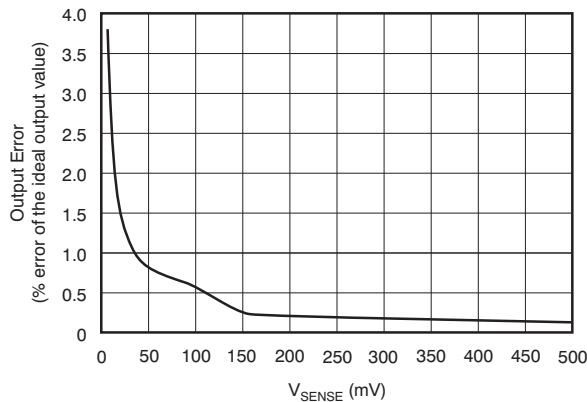


Figure 5. Output Error vs  $V_{SENSE}$

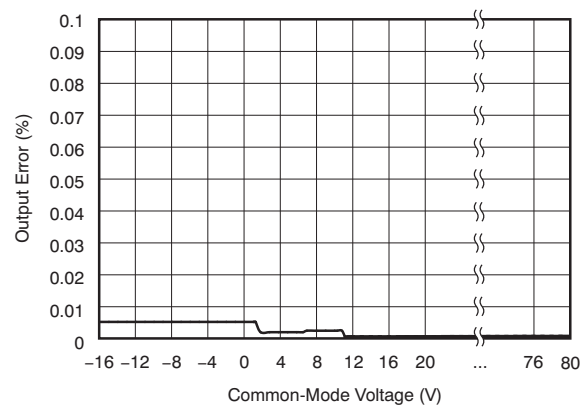


Figure 6. Output Error vs Common-Mode Voltage

### Typical Characteristics (continued)

All specifications at  $T_A = 25^\circ\text{C}$ ,  $V_S = 12\text{ V}$ , and  $V_{IN+} = 12\text{ V}$ , and  $V_{SENSE} = 100\text{ mV}$ , unless otherwise noted.

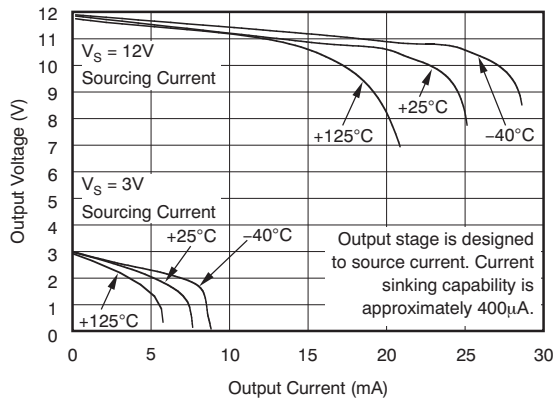


Figure 7. Positive Output Voltage Swing vs Output Current

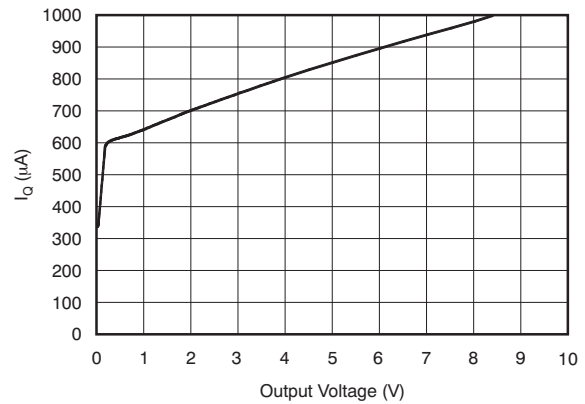


Figure 8. Quiescent Current vs Output Voltage

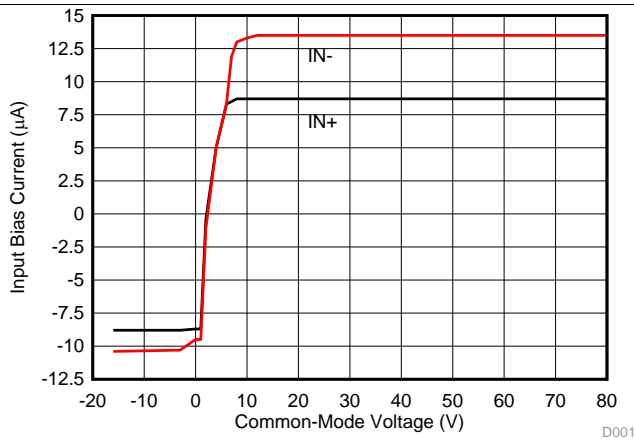


Figure 9. Input Bias Current vs Common Mode Voltage  
 $V_S = 5\text{ V}$

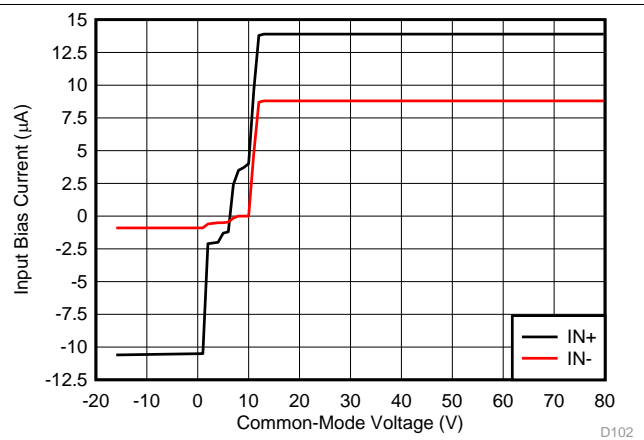


Figure 10. Input Bias Current vs Common Mode Voltage  
 $V_S = 12\text{ V}$

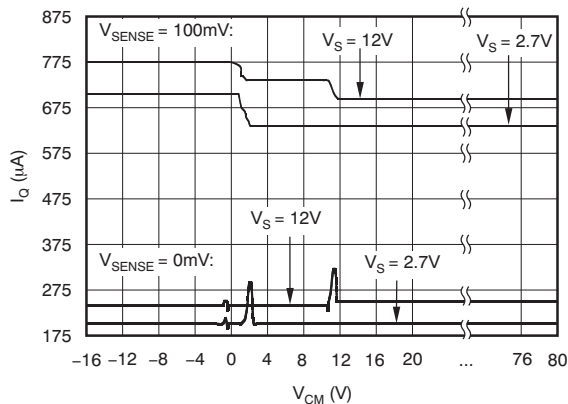


Figure 11. Quiescent Current vs Common-Mode Voltage

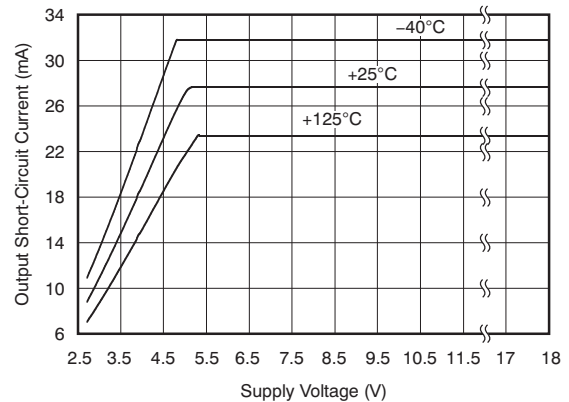
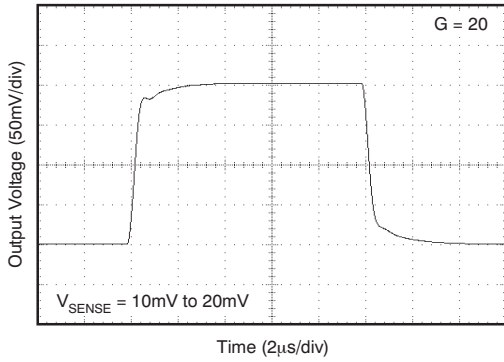


Figure 12. Output Short-Circuit Current vs Supply Voltage

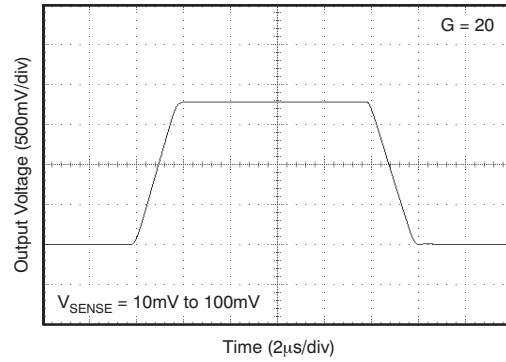


**Typical Characteristics (continued)**

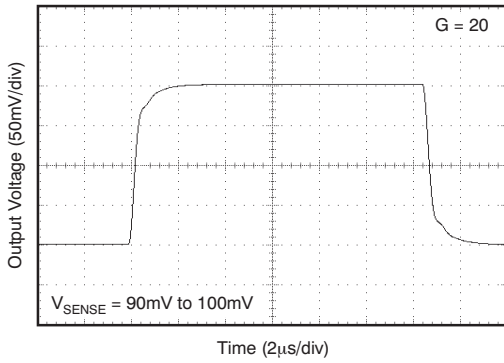
All specifications at  $T_A = 25^\circ\text{C}$ ,  $V_S = 12\text{ V}$ , and  $V_{IN+} = 12\text{ V}$ , and  $V_{SENSE} = 100\text{ mV}$ , unless otherwise noted.



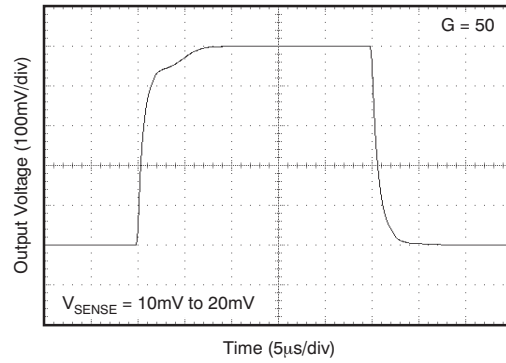
**Figure 13. Step Response**



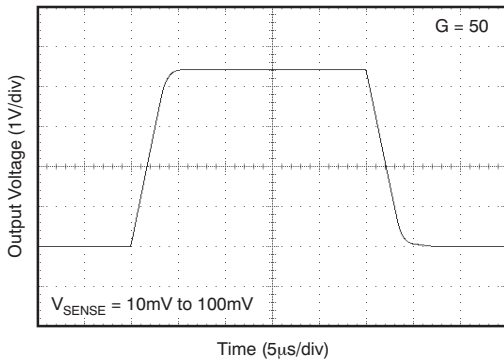
**Figure 14. Step Response**



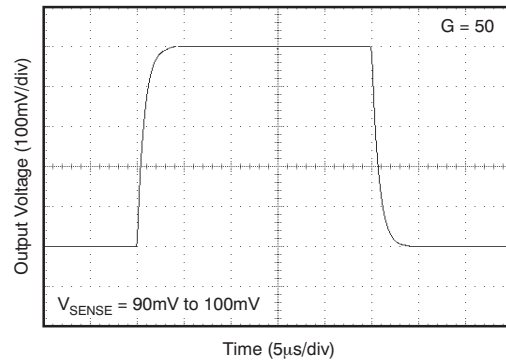
**Figure 15. Step Response**



**Figure 16. Step Response**



**Figure 17. Step Response**



**Figure 18. Step Response**

## Typical Characteristics (continued)

All specifications at  $T_A = 25^\circ\text{C}$ ,  $V_S = 12\text{ V}$ , and  $V_{IN+} = 12\text{ V}$ , and  $V_{SENSE} = 100\text{ mV}$ , unless otherwise noted.

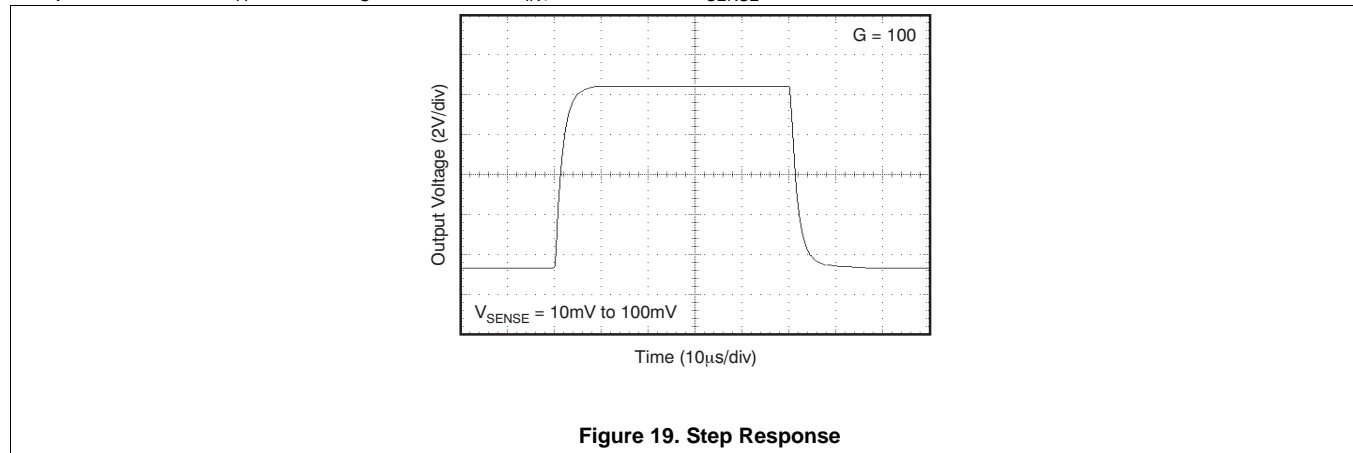


Figure 19. Step Response

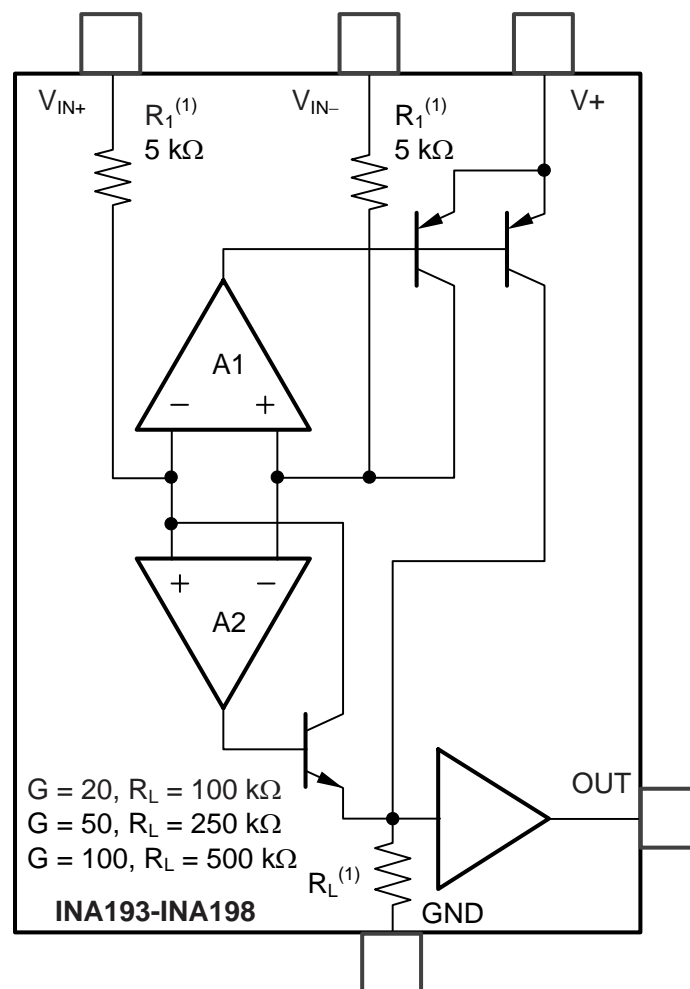
## 8 Detailed Description

### 8.1 Overview

The INA193–INA198 family of current shunt monitors with voltage output can sense drops across shunts at common-mode voltages from  $-16\text{ V}$  to  $+80\text{ V}$ , independent of the INA19x supply voltage. They are available with three output voltage scales: 20 V/V, 50 V/V, and 100 V/V. The 500-kHz bandwidth simplifies use in current control loops. The INA193–INA195 devices provide identical functions but alternative pin configurations to the INA196–INA198, respectively.

The INA193–INA198 devices operate from a single  $+2.7\text{-V}$  to  $+18\text{-V}$  supply, drawing a maximum of  $900\text{ }\mu\text{A}$  of supply current. They are specified over the extended operating temperature range ( $-40^\circ\text{C}$  to  $+125^\circ\text{C}$ ), and are offered in a space-saving SOT-23 package.

### 8.2 Functional Block Diagram



## 8.3 Feature Description

### 8.3.1 Basic Connection

Figure 20 shows the basic connection of the INA193-INA198. To minimize any resistance in series with the shunt resistor, connect the input pins,  $V_{IN+}$  and  $V_{IN-}$ , as closely as possible to the shunt resistor.

Power-supply bypass capacitors are required for stability. Applications with noisy or high impedance power supplies may require additional decoupling capacitors to reject power-supply noise. Connect bypass capacitors close to the device pins.

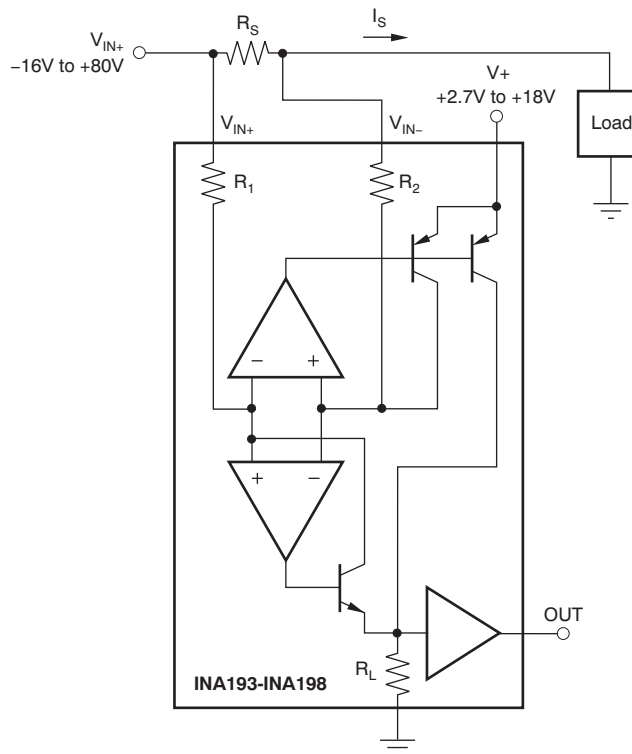


Figure 20. INA193-INA198 Basic Connection

### 8.3.2 Selecting $R_S$

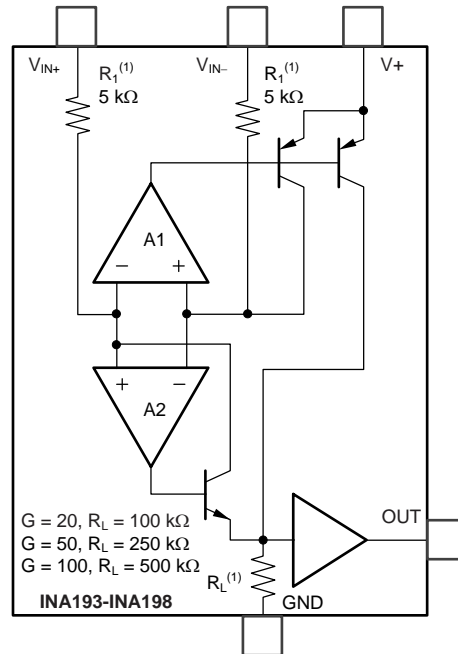
The value chosen for the shunt resistor,  $R_S$ , depends on the application and is a compromise between small-signal accuracy and maximum permissible voltage loss in the measurement line. High values of  $R_S$  provide better accuracy at lower currents by minimizing the effects of offset, while low values of  $R_S$  minimize voltage loss in the supply line. For most applications, best performance is attained with an  $R_S$  value that provides a full-scale shunt voltage range of 50 mV to 100 mV. Maximum input voltage for accurate measurements is 500 mV.

### 8.3.3 Inside the INA193-INA198

The INA193-INA198 devices use a new, unique internal circuit topology that provides common-mode range extending from  $-16$  to  $80$  V while operating from a single power supply. The common-mode rejection in a classic instrumentation amplifier approach is limited by the requirement for accurate resistor matching. By converting the induced input voltage to a current, the INA193-INA198 devices provide common-mode rejection that is no longer a function of closely matched resistor values, providing the enhanced performance necessary for such a wide common-mode range. A simplified diagram (shown in Figure 21) shows the basic circuit function. When the common-mode voltage is positive, amplifier A2 is active.

**Feature Description (continued)**

The differential input voltage,  $(V_{IN+}) - (V_{IN-})$  applied across  $R_S$ , is converted to a current through a resistor. This current is converted back to a voltage through  $R_L$ , and then amplified by the output buffer amplifier. When the common-mode voltage is negative, amplifier A1 is active. The differential input voltage,  $(V_{IN+}) - (V_{IN-})$  applied across  $R_S$ , is converted to a current through a resistor. This current is sourced from a precision current mirror whose output is directed into  $R_L$  converting the signal back into a voltage and amplified by the output buffer amplifier. Patent-pending circuit architecture ensures smooth device operation, even during the transition period where both amplifiers A1 and A2 are active.



(1) Nominal resistor values are shown.  $\pm 15\%$  variation is possible. Resistor ratios are matched to  $\pm 1\%$ .

**Figure 21. INA193-INA198 Simplified Circuit Diagram**

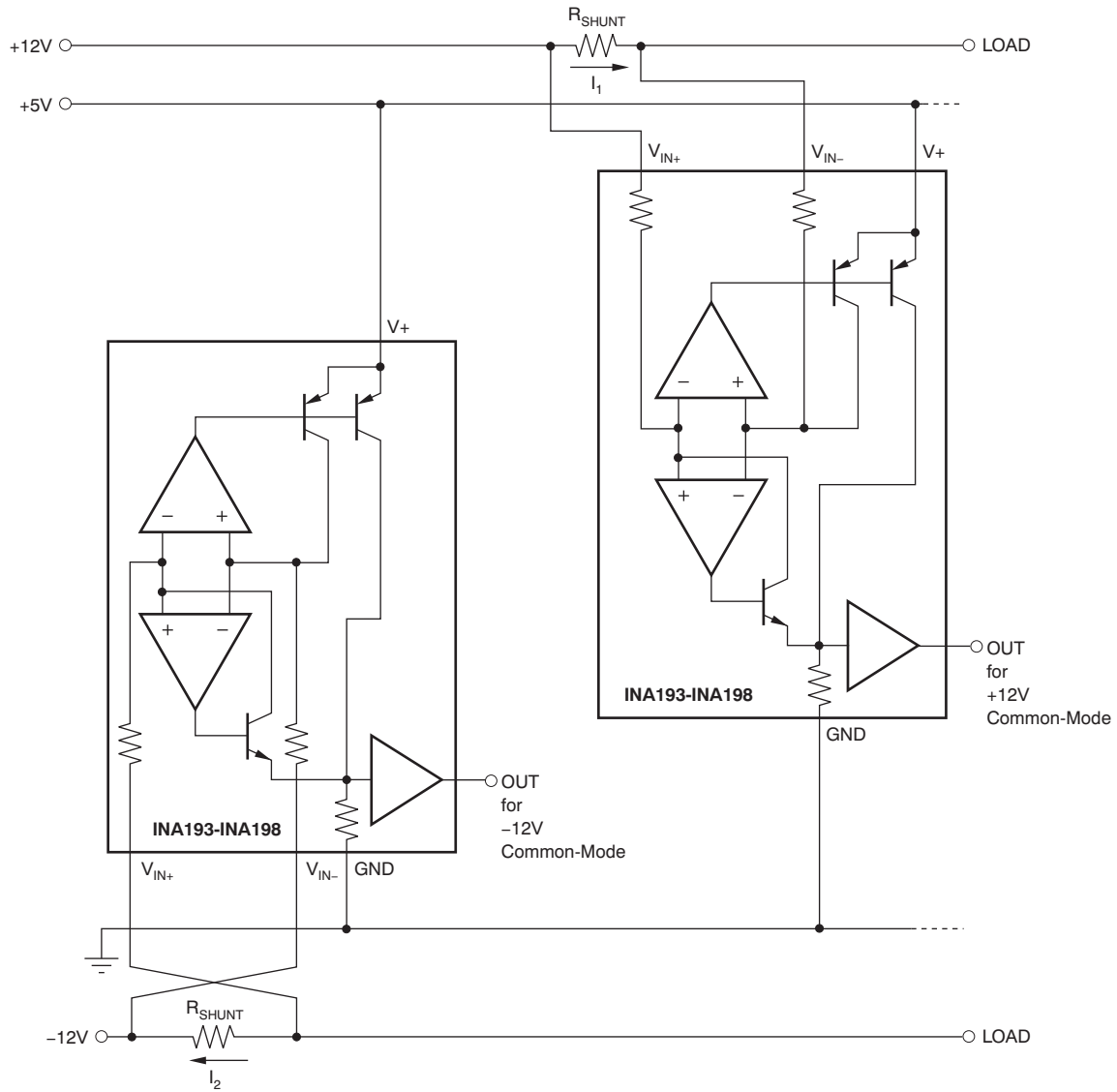


Figure 22. Monitor Bipolar Output Power-Supply Current

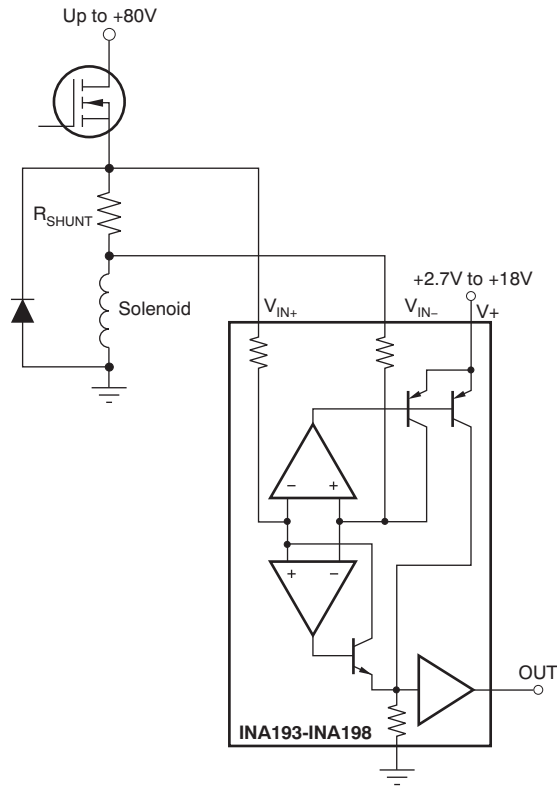
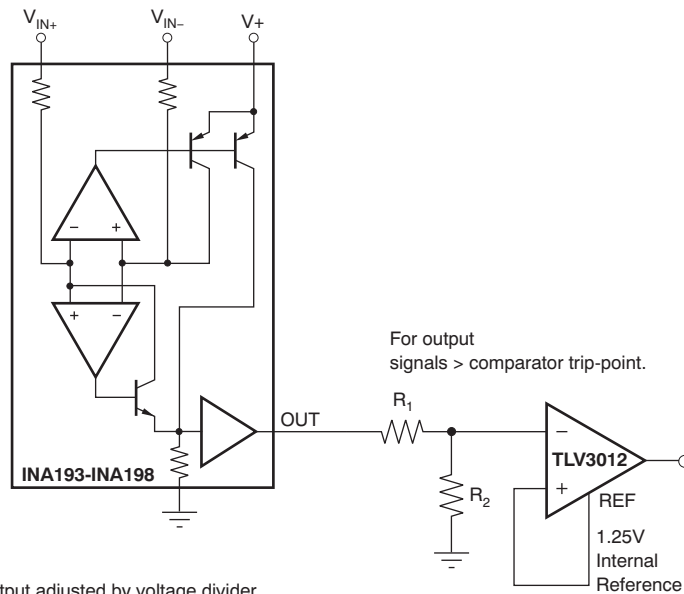
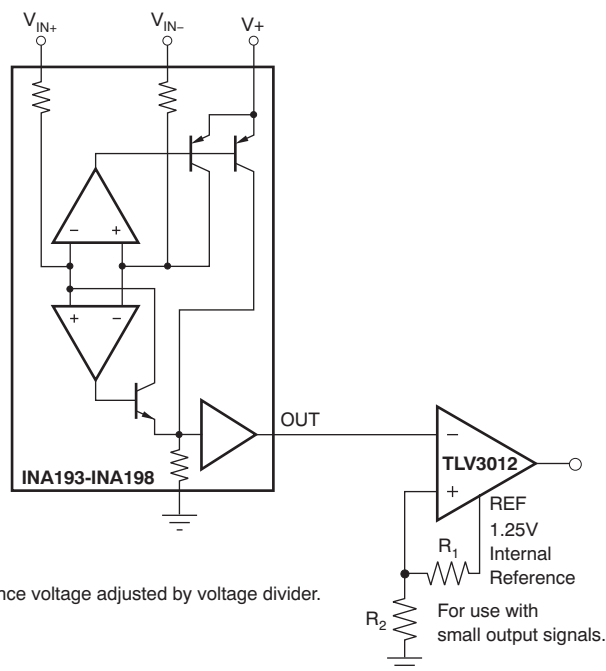


Figure 23. Inductive Current Monitor Including Flyback



(a) INA193-INA198 output adjusted by voltage divider.



(b) Comparator reference voltage adjusted by voltage divider.

Figure 24. INA193-INA198 with Comparator

## 8.4 Device Functional Modes

### 8.4.1 Input Filtering

An obvious and straightforward location for filtering is at the output of the INA193-INA198 devices; however, this location negates the advantage of the low output impedance of the internal buffer. The only other option for filtering is at the input pins of the INA193-INA198 devices, which is complicated by the internal 5-k $\Omega$  + 30% input impedance; this is illustrated in [Figure 25](#). Using the lowest possible resistor values minimizes both the initial shift in gain and effects of tolerance. The effect on initial gain is given by [Equation 1](#):



Device Functional Modes (continued)

$$\text{GainError\%} = 100 - \left( \frac{5\text{k}\Omega}{5\text{k}\Omega + R_{\text{FILT}}} \right) \times 100 \tag{1}$$

Total effect on gain error can be calculated by replacing the 5-kΩ term with 5 kΩ – 30%, (or 3.5 kΩ) or 5 kΩ + 30% (or 6.5 kΩ). The tolerance extremes of R<sub>FILT</sub> can also be inserted into the equation. If a pair of 100-Ω 1% resistors are used on the inputs, the initial gain error will be approximately 2%. Worst-case tolerance conditions will always occur at the lower excursion of the internal 5-kΩ resistor (3.5 kΩ), and the higher excursion of R<sub>FILT</sub> – 3% in this case.

Note that the specified accuracy of the INA193-INA198 devices must then be combined in addition to these tolerances. While this discussion treated accuracy worst-case conditions by combining the extremes of the resistor values, it is appropriate to use geometric mean or root sum square calculations to total the effects of accuracy variations.

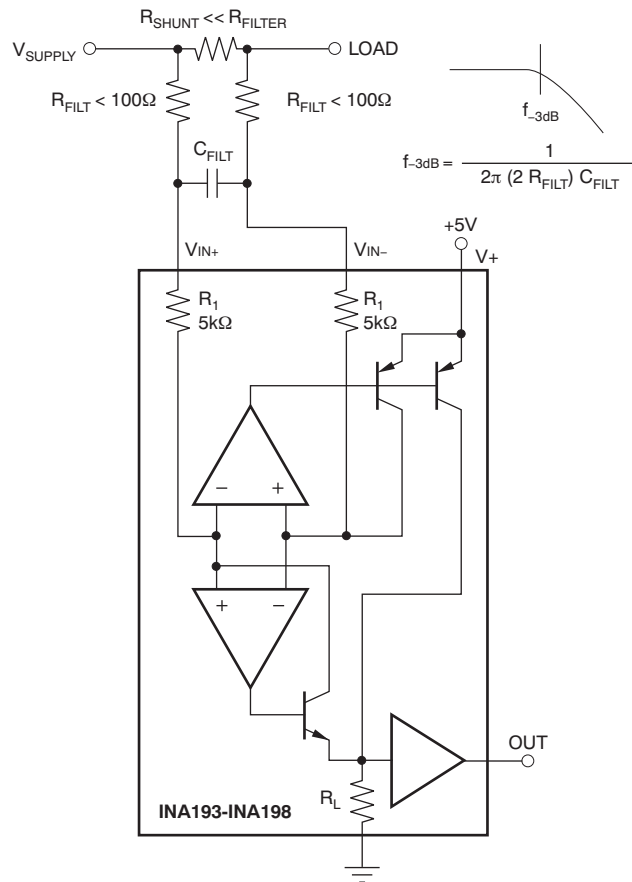


Figure 25. Input Filter (Gain Error – 1.5% To –2.2%)

8.4.2 Accuracy Variations as a Result of V<sub>SENSE</sub> and Common-Mode Voltage

The accuracy of the INA193-INA198 current shunt monitors is a function of two main variables: V<sub>SENSE</sub> (V<sub>IN+</sub> – V<sub>IN-</sub>) and common-mode voltage, V<sub>CM</sub>, relative to the supply voltage, V<sub>S</sub>. V<sub>CM</sub> is expressed as (V<sub>IN+</sub> + V<sub>IN-</sub>)/2; however, in practice, V<sub>CM</sub> is seen as the voltage at V<sub>IN+</sub> because the voltage drop across V<sub>SENSE</sub> is usually small.

This section addresses the accuracy of these specific operating regions:

- Normal Case 1: V<sub>SENSE</sub> ≥ 20mV, V<sub>CM</sub> ≥ V<sub>S</sub>
- Normal Case 2: V<sub>SENSE</sub> ≥ 20mV, V<sub>CM</sub> < V<sub>S</sub>
- Low V<sub>SENSE</sub> Case 1: V<sub>SENSE</sub> < 20mV, –16V ≤ V<sub>CM</sub> < 0
- Low V<sub>SENSE</sub> Case 2: V<sub>SENSE</sub> < 20mV, 0V ≤ V<sub>CM</sub> ≤ V<sub>S</sub>

## Device Functional Modes (continued)

Low  $V_{\text{SENSE}}$  Case 3:  $V_{\text{SENSE}} < 20\text{mV}$ ,  $V_{\text{S}} < V_{\text{CM}} \leq 80\text{V}$

### 8.4.2.1 Normal Case 1: $V_{\text{SENSE}} \geq 20\text{mV}$ , $V_{\text{CM}} \geq V_{\text{S}}$

This region of operation provides the highest accuracy. Here, the input offset voltage is characterized and measured using a two-step method. First, the gain is determined by [Equation 2](#).

$$G = \frac{V_{\text{OUT1}} - V_{\text{OUT2}}}{100\text{mV} - 20\text{mV}}$$

where:

$V_{\text{OUT1}}$  = Output Voltage with  $V_{\text{SENSE}} = 100\text{mV}$

$V_{\text{OUT2}}$  = Output Voltage with  $V_{\text{SENSE}} = 20\text{mV}$

(2)

Then the offset voltage is measured at  $V_{\text{SENSE}} = 100\text{mV}$  and referred to the input (RTI) of the current shunt monitor, as shown in [Equation 3](#).

$$V_{\text{OSRTI}} \text{ (Referred-To-Input)} = \left[ \frac{V_{\text{OUT1}}}{G} \right] - 100\text{mV}$$

(3)

In the [Typical Characteristics](#), the *Output Error vs Common-Mode Voltage* curve ([Figure 6](#)) shows the highest accuracy for this region of operation. In this plot,  $V_{\text{S}} = 12\text{V}$ ; for  $V_{\text{CM}} \geq 12\text{V}$ , the output error is at its minimum. This case is also used to create the  $V_{\text{SENSE}} \geq 20\text{-mV}$  output specifications in the [Electrical Characteristics](#) table.

### 8.4.2.2 Normal Case 2: $V_{\text{SENSE}} \geq 20\text{mV}$ , $V_{\text{CM}} < V_{\text{S}}$

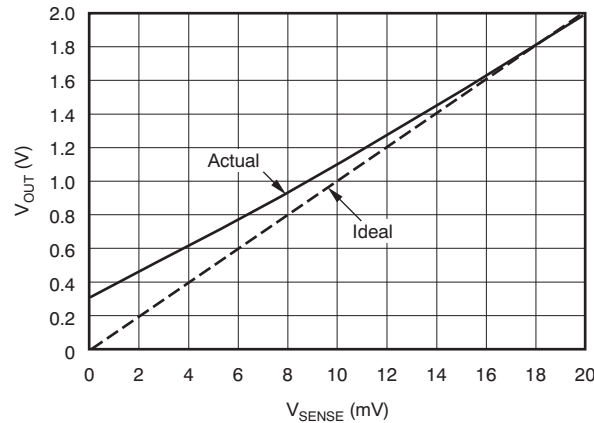
This region of operation has slightly less accuracy than Normal Case 1 as a result of the common-mode operating area in which the part functions, as seen in the *Output Error vs Common-Mode Voltage* curve ([Figure 6](#)). As noted, for this graph  $V_{\text{S}} = 12\text{V}$ ; for  $V_{\text{CM}} < 12\text{V}$ , the Output Error increases as  $V_{\text{CM}}$  becomes less than  $12\text{V}$ , with a typical maximum error of 0.005% at the most negative  $V_{\text{CM}} = -16\text{V}$ .

**Device Functional Modes (continued)**

**8.4.2.3 Low  $V_{SENSE}$  Case 1:  $V_{SENSE} < 20\text{mV}$ ,  $-16\text{V} \leq V_{CM} < 0$ ; and Low  $V_{SENSE}$  Case 3:  $V_{SENSE} < 20\text{mV}$ ,  $V_S < V_{CM} \leq 80\text{V}$**

Although the INA193–INA198 family of devices are not designed for accurate operation in either of these regions, some applications are exposed to these conditions; for example, when monitoring power supplies that are switched on and off while  $V_S$  is still applied to the INA193–INA198 devices. It is important to know what the behavior of the devices will be in these regions.

As  $V_{SENSE}$  approaches 0 mV, in these  $V_{CM}$  regions, the device output accuracy degrades. A larger-than-normal offset can appear at the current shunt monitor output with a typical maximum value of  $V_{OUT} = 300\text{ mV}$  for  $V_{SENSE} = 0\text{ mV}$ . As  $V_{SENSE}$  approaches 20 mV,  $V_{OUT}$  returns to the expected output value with accuracy as specified in the [Electrical Characteristics](#). [Figure 26](#) illustrates this effect using the INA195 and INA198 devices (Gain = 100).

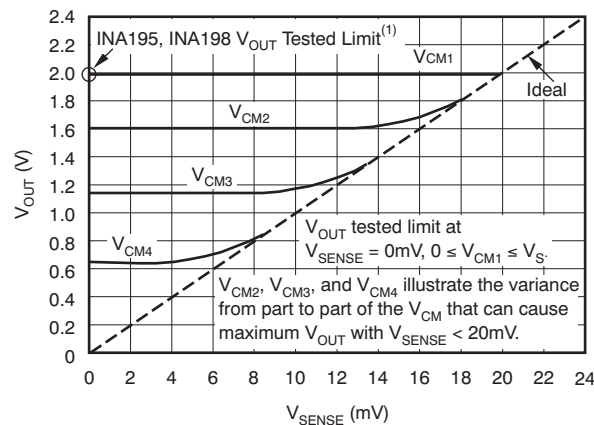


**Figure 26. Example for Low  $V_{SENSE}$  Cases 1 and 3 (INA195, INA198: Gain = 100)**

**8.4.2.4 Low  $V_{SENSE}$  Case 2:  $V_{SENSE} < 20\text{ mV}$ ,  $0\text{ V} \leq V_{CM} \leq V_S$**

This region of operation is the least accurate for the INA193–INA198 family of devices. To achieve the wide input common-mode voltage range, these devices use two op amp front ends in parallel. One op amp front end operates in the positive input common-mode voltage range, and the other in the negative input region. For this case, neither of these two internal amplifiers dominates and overall loop gain is very low. Within this region,  $V_{OUT}$  approaches voltages close to linear operation levels for Normal Case 2. This deviation from linear operation becomes greatest the closer  $V_{SENSE}$  approaches 0 V. Within this region, as  $V_{SENSE}$  approaches 20 mV, device operation is closer to that described by Normal Case 2. [Figure 27](#) illustrates this behavior for the INA195 device. The  $V_{OUT}$  maximum peak for this case is tested by maintaining a constant  $V_S$ , setting  $V_{SENSE} = 0\text{ mV}$  and sweeping  $V_{CM}$  from 0 V to  $V_S$ . The exact  $V_{CM}$  at which  $V_{OUT}$  peaks during this test varies from part to part, but the  $V_{OUT}$  maximum peak is tested to be less than the specified  $V_{OUT}$  Tested Limit.

## Device Functional Modes (continued)

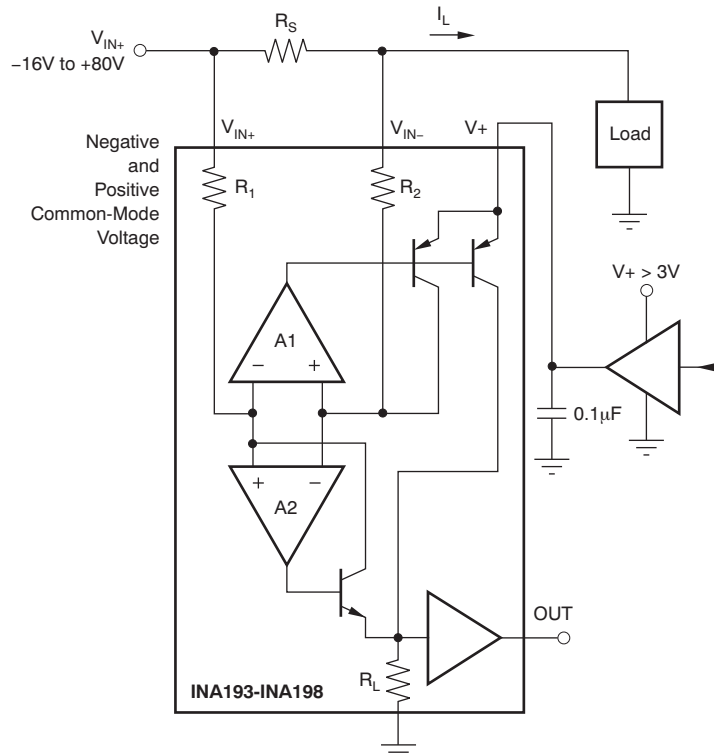


(1) INA193, INA196  $V_{OUT}$  Tested Limit = 0.4V. INA194, INA197  $V_{OUT}$  Tested Limit = 1V.

**Figure 27. Example for Low  $V_{SENSE}$  Case 2 (INA195, INA198: Gain = 100)**

### 8.4.3 Shutdown

Because the INA193-INA198 devices consume a quiescent current less than 1 mA, they can be powered by either the output of logic gates or by transistor switches to supply power. Use a totem-pole output buffer or gate that can provide sufficient drive along with 0.1- $\mu$ F bypass capacitor, preferably ceramic with good high-frequency characteristics. This gate should have a supply voltage of 3 V or greater because the INA193-INA198 devices require a minimum supply greater than 2.7 V. In addition to eliminating quiescent current, this gate also turns off the 10- $\mu$ A bias current present at each of the inputs. An example shutdown circuit is shown in [Figure 28](#).



**Figure 28. INA193-INA198 Example Shutdown Circuit**

## Device Functional Modes (continued)

### 8.4.4 Transient Protection

The  $-16\text{-V}$  to  $+80\text{-V}$  common-mode range of the INA193-INA198 devices is ideal for withstanding automotive fault conditions ranging from 12-V battery reversal up to 80-V transients, since no additional protective components are needed up to those levels. In the event that the INA193-INA198 devices are exposed to transients on the inputs in excess of its ratings, then external transient absorption with semiconductor transient absorbers (zeners or Transzorbs) will be necessary. Use of MOVs or VDRs is not recommended except when they are used in addition to a semiconductor transient absorber. Select the transient absorber such that it will never allow the INA193-INA198 devices to be exposed to transients greater than  $+80\text{ V}$  (that is, allow for transient absorber tolerance, as well as additional voltage due to transient absorber dynamic impedance). Despite the use of internal zener-type ESD protection, the INA193-INA198 devices do not lend themselves to using external resistors in series with the inputs because the internal gain resistors can vary up to  $\pm 30\%$ . (If gain accuracy is not important, then resistors can be added in series with the INA193-INA198 inputs with two equal resistors on each input.)

### 8.4.5 Output Voltage Range

The output of the INA193-INA198 devices are accurate within the output voltage swing range set by the power-supply pin,  $V+$ . This is best illustrated when using the INA195 or INA198 devices (which are both versions using a gain of 100), where a 100-mV full-scale input from the shunt resistor requires an output voltage swing of  $+10\text{ V}$ , and a power-supply voltage sufficient to achieve  $+10\text{ V}$  on the output.

## 9 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.

### 9.1 Application Information

The INA193-INA198 devices measure the voltage developed across a current-sensing resistor when current passes through it. The ability to have shunt common-mode voltages from  $-16\text{-V}$  to  $+80\text{-V}$  drive and control the output signal with  $V_S$  offers multiple configurations, as discussed throughout this section.

### 9.2 Typical Application

The device is a unidirectional, current-sense amplifier capable of measuring currents through a resistive shunt with shunt common-mode voltages from  $-16\text{ V}$  to  $80\text{ V}$ . Two devices can be configured for bidirectional monitoring and is common in applications that include charging and discharging operations where the current flow-through resistor can change directions.

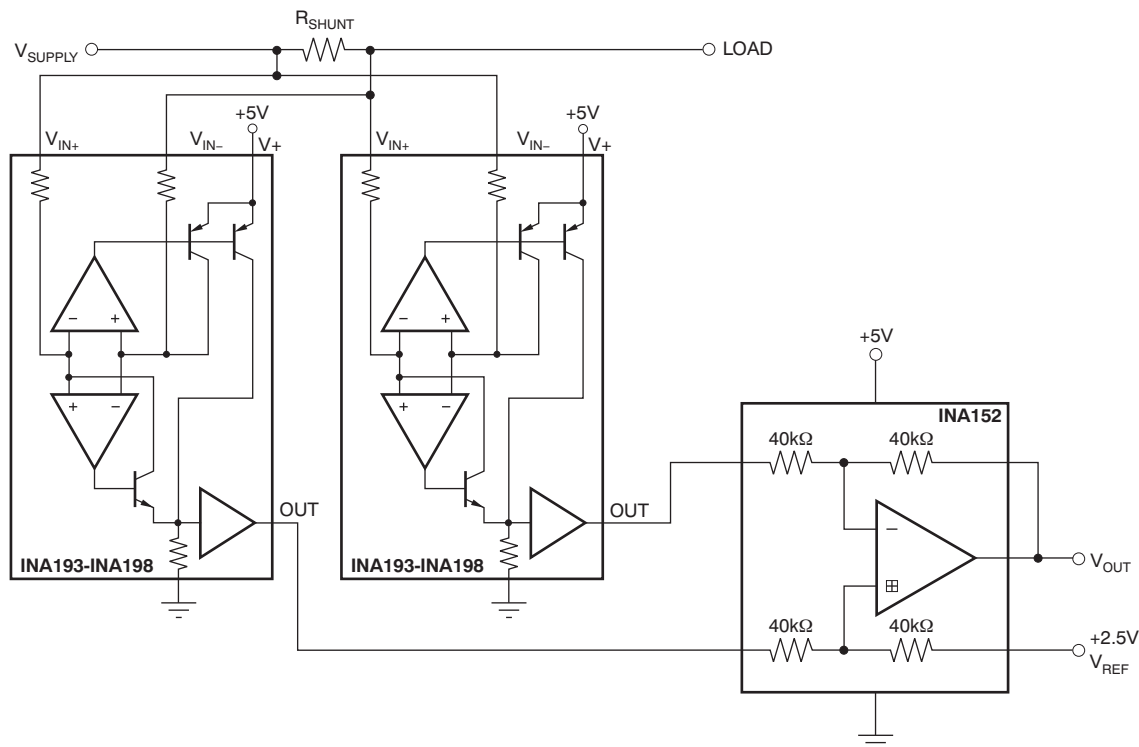


Figure 29. Bi-Directional Current Monitoring

#### 9.2.1 Design Requirements

$V_{supply}$  is set to  $12\text{ V}$ ,  $V_{ref}$  at  $2.5\text{ V}$  and a  $10\text{-m}\Omega$  shunt. The accuracy of the current will typically be less than  $0.5\%$  for current greater than  $\pm 2\text{ A}$ . For current lower than  $\pm 2\text{ A}$ , the accuracy will vary; use the [Device Functional Modes](#) section for accuracy considerations.

## Typical Application (continued)

### 9.2.2 Detailed Design Procedure

The ability to measure this current flowing in both directions is enabled by adding a unity gain amplifier with a  $V_{REF}$ , as shown in Figure 29. The output then responds by increasing above  $V_{REF}$  for positive differential signals (relative to the IN – pin) and responds by decreasing below  $V_{REF}$  for negative differential signals. This reference voltage applied to the REF pin can be set anywhere between 0 V to  $V_+$ . For bidirectional applications,  $V_{REF}$  is typically set at mid-scale for equal signal range in both current directions. In some cases, however,  $V_{REF}$  is set at a voltage other than mid-scale when the bidirectional current and corresponding output signal do not need to be symmetrical.

### 9.2.3 Application Curve

An example output response of a bidirectional configuration is shown in Figure 30. With the REF pin connected to a reference voltage, 2.5 V in this case, the output voltage is biased upwards by this reference level. The output rises above the reference voltage for positive differential input signals and falls below the reference voltage for negative differential input signals.

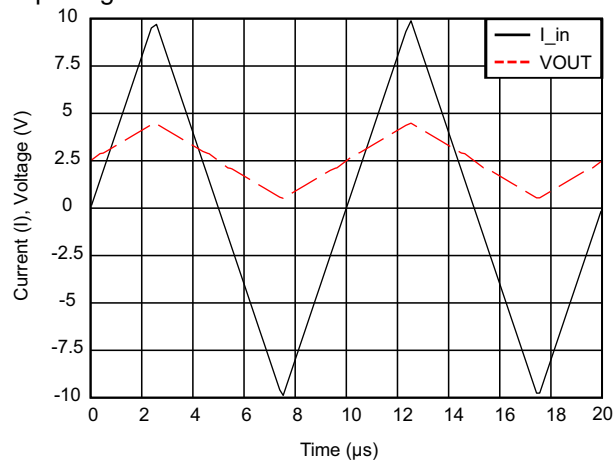


Figure 30. Output Voltage vs Shunt Input Current

## 10 Power Supply Recommendations

The input circuitry of the INA193-INA198 devices can accurately measure beyond its power-supply voltage,  $V_+$ . For example, the  $V_+$  power supply can be 5 V, whereas the load power-supply voltage is up to 80 V. The output voltage range of the OUT terminal, however, is limited by the voltages on the power-supply pin.

## 11 Layout

### 11.1 Layout Guidelines

#### 11.1.1 RFI and EMI

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. Small ceramic capacitors placed directly across amplifier inputs can reduce RFI/EMI sensitivity. PCB layout should locate the amplifier as far away as possible from RFI sources. Sources can include other components in the same system as the amplifier itself, such as inductors (particularly switched inductors handling a lot of current and at high frequencies). RFI can generally be identified as a variation in offset voltage or DC signal levels with changes in the interfering RF signal. If the amplifier cannot be located away from sources of radiation, shielding may be needed. Twisting wire input leads makes them more resistant to RF fields. The difference in input pin location of the INA193-INA195 devices versus the INA196-INA198 devices may provide different EMI performance.

## 11.2 Layout Example

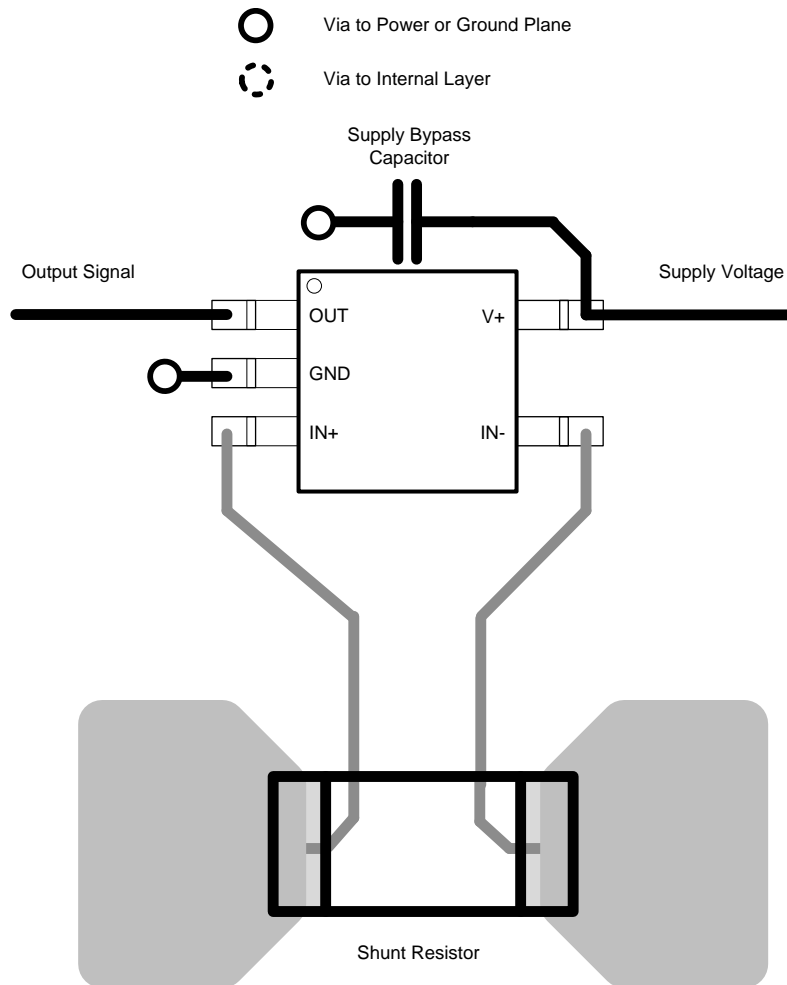


Figure 31. Recommended Layout



## 12 器件和文档支持

### 12.1 相关链接

下面的表格列出了快速访问链接。范围包括技术文档、支持和社区资源、工具和软件，以及样片或购买的快速访问。

表 1. 相关链接

| 器件     | 产品文件夹                 | 样片与购买                 | 技术文档                  | 工具与软件                 | 支持与社区                 |
|--------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| INA193 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| INA194 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| INA195 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| INA196 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| INA197 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| INA198 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |

### 12.2 商标

All trademarks are the property of their respective owners.

### 12.3 静电放电警告



这些装置包含有限的内置 ESD 保护。存储或装卸时，应将导线一起截短或将装置放置于导电泡棉中，以防止 MOS 门极遭受静电损伤。

### 12.4 Glossary

[SLYZ022](#) — *TI Glossary*.

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

## 13 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。

**PACKAGING INFORMATION**

| Orderable part number        | Status<br>(1) | Material type<br>(2) | Package   Pins   | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">INA193AIDBVR</a> | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU   SN                          | Level-2-260C-1 YEAR               | -40 to 125   | BJJ                 |
| INA193AIDBVR.A               | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJJ                 |
| INA193AIDBVR1G4              | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJJ                 |
| INA193AIDBVR1G4.A            | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJJ                 |
| <a href="#">INA193AIDBVT</a> | Active        | Production           | SOT-23 (DBV)   5 | 250   SMALL T&R       | Yes         | NIPDAU   SN                          | Level-2-260C-1 YEAR               | -40 to 125   | BJJ                 |
| INA193AIDBVT.A               | Active        | Production           | SOT-23 (DBV)   5 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJJ                 |
| <a href="#">INA194AIDBVR</a> | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU   SN                          | Level-2-260C-1 YEAR               | -40 to 125   | BJI                 |
| INA194AIDBVR.A               | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJI                 |
| INA194AIDBVR1G4              | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJI                 |
| INA194AIDBVR1G4.A            | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJI                 |
| <a href="#">INA194AIDBVT</a> | Active        | Production           | SOT-23 (DBV)   5 | 250   SMALL T&R       | Yes         | NIPDAU   SN                          | Level-2-260C-1 YEAR               | -40 to 125   | BJI                 |
| INA194AIDBVT.A               | Active        | Production           | SOT-23 (DBV)   5 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJI                 |
| <a href="#">INA195AIDBVR</a> | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU   SN                          | Level-2-260C-1 YEAR               | -40 to 125   | BJK                 |
| INA195AIDBVR.A               | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJK                 |
| INA195AIDBVRG4               | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJK                 |
| INA195AIDBVRG4.A             | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJK                 |
| <a href="#">INA195AIDBVT</a> | Active        | Production           | SOT-23 (DBV)   5 | 250   SMALL T&R       | Yes         | NIPDAU   SN                          | Level-2-260C-1 YEAR               | -40 to 125   | BJK                 |
| INA195AIDBVT.A               | Active        | Production           | SOT-23 (DBV)   5 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJK                 |
| <a href="#">INA196AIDBVR</a> | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJE                 |
| INA196AIDBVR.A               | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJE                 |
| INA196AIDBVR1G4              | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJE                 |
| INA196AIDBVR1G4.A            | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJE                 |
| <a href="#">INA196AIDBVT</a> | Active        | Production           | SOT-23 (DBV)   5 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJE                 |
| INA196AIDBVT.A               | Active        | Production           | SOT-23 (DBV)   5 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJE                 |
| <a href="#">INA197AIDBVR</a> | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJH                 |
| INA197AIDBVR.A               | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJH                 |
| INA197AIDBVR1G4              | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJH                 |
| INA197AIDBVR1G4.A            | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJH                 |
| <a href="#">INA197AIDBVT</a> | Active        | Production           | SOT-23 (DBV)   5 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJH                 |

| Orderable part number        | Status<br>(1) | Material type<br>(2) | Package   Pins   | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| INA197AIDBVT.A               | Active        | Production           | SOT-23 (DBV)   5 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJH                 |
| <a href="#">INA198AIDBVR</a> | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJL                 |
| INA198AIDBVR.A               | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJL                 |
| INA198AIDBVRG4               | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJL                 |
| INA198AIDBVRG4.A             | Active        | Production           | SOT-23 (DBV)   5 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJL                 |
| <a href="#">INA198AIDBVT</a> | Active        | Production           | SOT-23 (DBV)   5 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJL                 |
| INA198AIDBVT.A               | Active        | Production           | SOT-23 (DBV)   5 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 125   | BJL                 |

(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.

**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**

**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 |
|-----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| INA193AIDBVR    | SOT-23       | DBV             | 5    | 3000 | 180.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| INA193AIDBVR1G4 | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.23    | 3.17    | 1.37    | 4.0     | 8.0    | Q3            |
| INA193AIDBVT    | SOT-23       | DBV             | 5    | 250  | 180.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| INA194AIDBVR    | SOT-23       | DBV             | 5    | 3000 | 180.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| INA194AIDBVR1G4 | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.23    | 3.17    | 1.37    | 4.0     | 8.0    | Q3            |
| INA194AIDBVT    | SOT-23       | DBV             | 5    | 250  | 178.0              | 9.0                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| INA194AIDBVT    | SOT-23       | DBV             | 5    | 250  | 180.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| INA195AIDBVR    | SOT-23       | DBV             | 5    | 3000 | 180.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| INA195AIDBVR    | SOT-23       | DBV             | 5    | 3000 | 180.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| INA195AIDBVRG4  | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| INA195AIDBVT    | SOT-23       | DBV             | 5    | 250  | 180.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| INA196AIDBVR    | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| INA196AIDBVR1G4 | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| INA196AIDBVT    | SOT-23       | DBV             | 5    | 250  | 178.0              | 9.0                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| INA197AIDBVR    | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| INA197AIDBVR1G4 | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |

| 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 |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| INA197AIDBVT   | SOT-23       | DBV             | 5    | 250  | 178.0              | 9.0                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| INA198AIDBVR   | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| INA198AIDBVRG4 | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| INA198AIDBVT   | SOT-23       | DBV             | 5    | 250  | 178.0              | 9.0                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

| Device          | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| INA193AIDBVR    | SOT-23       | DBV             | 5    | 3000 | 210.0       | 185.0      | 35.0        |
| INA193AIDBVR1G4 | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| INA193AIDBVT    | SOT-23       | DBV             | 5    | 250  | 210.0       | 185.0      | 35.0        |
| INA194AIDBVR    | SOT-23       | DBV             | 5    | 3000 | 210.0       | 185.0      | 35.0        |
| INA194AIDBVR1G4 | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| INA194AIDBVT    | SOT-23       | DBV             | 5    | 250  | 180.0       | 180.0      | 18.0        |
| INA194AIDBVT    | SOT-23       | DBV             | 5    | 250  | 210.0       | 185.0      | 35.0        |
| INA195AIDBVR    | SOT-23       | DBV             | 5    | 3000 | 210.0       | 185.0      | 35.0        |
| INA195AIDBVR    | SOT-23       | DBV             | 5    | 3000 | 210.0       | 185.0      | 35.0        |
| INA195AIDBVRG4  | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| INA195AIDBVT    | SOT-23       | DBV             | 5    | 250  | 210.0       | 185.0      | 35.0        |
| INA196AIDBVR    | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| INA196AIDBVR1G4 | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| INA196AIDBVT    | SOT-23       | DBV             | 5    | 250  | 180.0       | 180.0      | 18.0        |
| INA197AIDBVR    | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| INA197AIDBVR1G4 | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| INA197AIDBVT    | SOT-23       | DBV             | 5    | 250  | 180.0       | 180.0      | 18.0        |
| INA198AIDBVR    | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |

---

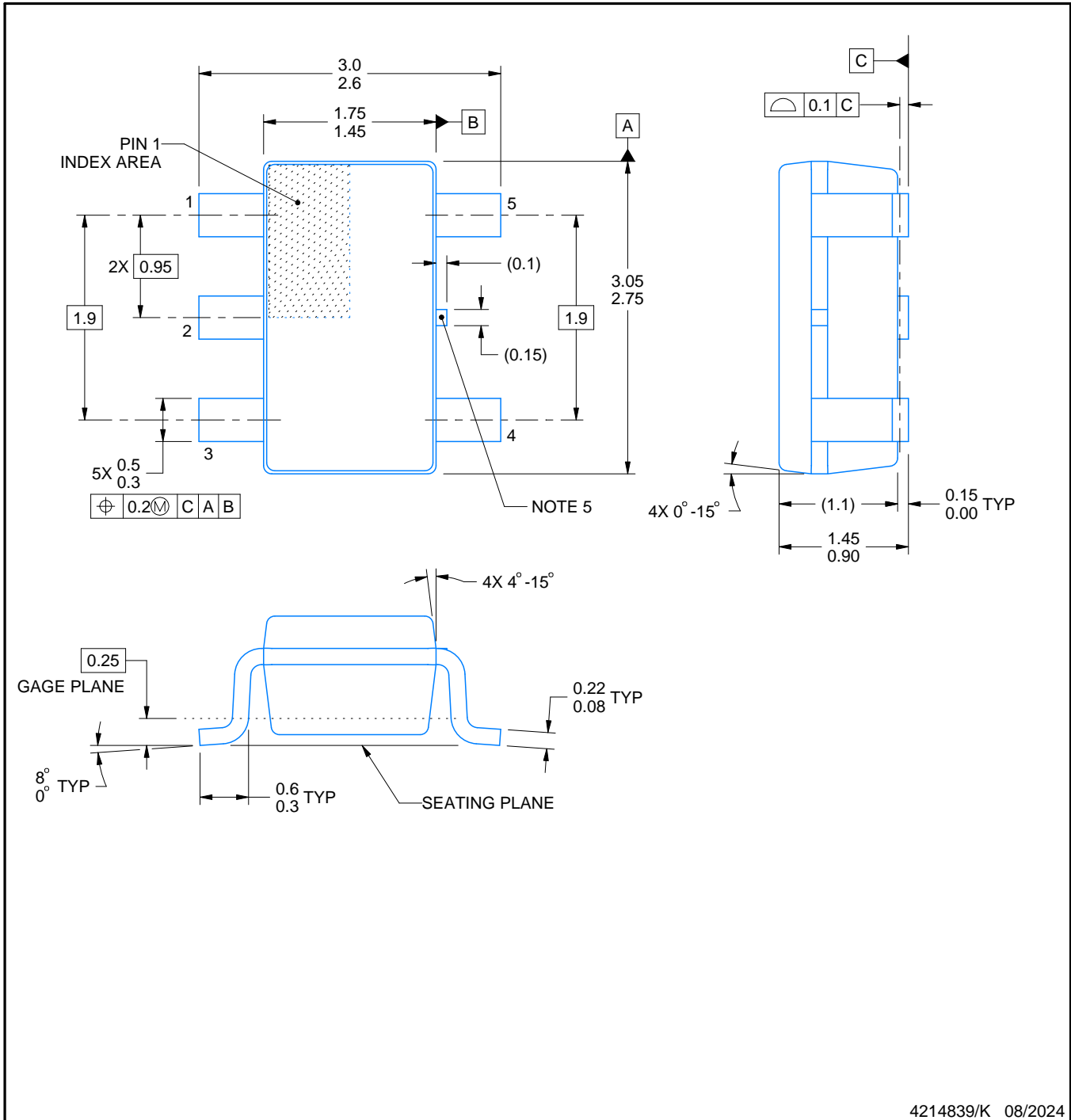
| Device         | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| INA198AIDBVRG4 | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| INA198AIDBVT   | SOT-23       | DBV             | 5    | 250  | 180.0       | 180.0      | 18.0        |

# DBV0005A



# PACKAGE OUTLINE SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



4214839/K 08/2024

## NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC MO-178.
4. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25 mm per side.
5. Support pin may differ or may not be present.



# EXAMPLE BOARD LAYOUT

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:15X



SOLDER MASK DETAILS

4214839/K 08/2024

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

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:15X

4214839/K 08/2024

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.

## 重要通知和免责声明

TI“按原样”提供技术和可靠性数据（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，不保证没有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、与某特定用途的适用性或不侵犯任何第三方知识产权的暗示担保。

这些资源可供使用 TI 产品进行设计的熟练开发人员使用。您将自行承担以下全部责任：(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、安保法规或其他要求。

这些资源如有变更，恕不另行通知。TI 授权您仅可将这些资源用于研发本资源所述的 TI 产品的相关应用。严禁以其他方式对这些资源进行复制或展示。您无权使用任何其他 TI 知识产权或任何第三方知识产权。对于因您对这些资源的使用而对 TI 及其代表造成的任何索赔、损害、成本、损失和债务，您将全额赔偿，TI 对此概不负责。

TI 提供的产品受 [TI 销售条款](#)、[TI 通用质量指南](#) 或 [ti.com](#) 上其他适用条款或 TI 产品随附的其他适用条款的约束。TI 提供这些资源并不会扩展或以其他方式更改 TI 针对 TI 产品发布的适用的担保或担保免责声明。除非德州仪器 (TI) 明确将某产品指定为定制产品或客户特定产品，否则其产品均为按确定价格收入目录的标准通用器件。

TI 反对并拒绝您可能提出的任何其他或不同的条款。

版权所有 © 2025，德州仪器 (TI) 公司

最后更新日期：2025 年 10 月