



High-Side Measurement Current-Shunt Monitor with Open-Drain Comparator and Reference

Check for Samples: [INA200](#), [INA201](#), [INA202](#)

FEATURES

- COMPLETE CURRENT SENSE SOLUTION
- 0.6V INTERNAL VOLTAGE REFERENCE
- INTERNAL OPEN-DRAIN COMPARATOR
- LATCHING CAPABILITY ON COMPARATOR
- COMMON-MODE RANGE: -16V to $+80\text{V}$
- HIGH ACCURACY: 3.5% MAX ERROR OVER TEMPERATURE
- BANDWIDTH: 500kHz (INA200)
- QUIESCENT CURRENT: 1800 μA (max)
- PACKAGES: SO-8, MSOP-8

APPLICATIONS

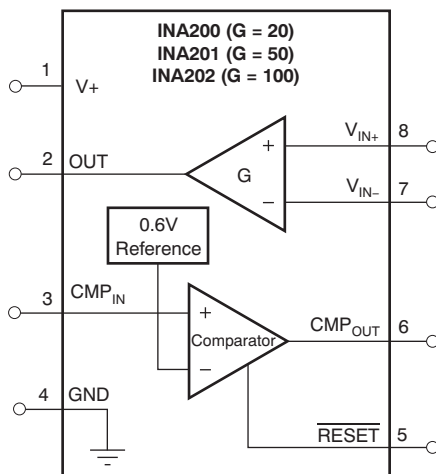
- NOTEBOOK COMPUTERS
- CELL PHONES
- TELECOM EQUIPMENT
- AUTOMOTIVE
- POWER MANAGEMENT
- BATTERY CHARGERS
- WELDING EQUIPMENT

DESCRIPTION

The INA200, INA201, and INA202 are high-side current-shunt monitors with voltage output. The INA200–INA202 can sense drops across shunts at common-mode voltages from -16V to 80V . The INA200–INA202 are available with three output voltage scales: 20V/V, 50V/V, and 100V/V, with up to 500kHz bandwidth.

The INA200, INA201, and INA202 also incorporate an open-drain comparator and internal reference providing a 0.6V threshold. External dividers are used to set the current trip point. The comparator includes a latching capability, which can be made transparent by grounding (or leaving open) the $\overline{\text{RESET}}$ pin.

The INA200, INA201, and INA202 operate from a single $+2.7\text{V}$ to $+18\text{V}$ supply, drawing a maximum of 1800 μA of supply current. Package options include the very small MSOP-8 and the SO-8. All versions are specified over the extended operating temperature range of -40°C to $+125^\circ\text{C}$.



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



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

ORDERING INFORMATION⁽¹⁾

| PRODUCT | GAIN | PACKAGE-LEAD | PACKAGE DESIGNATOR | PACKAGE MARKING |
|---------|--------|--------------|--------------------|-----------------|
| INA200 | 20V/V | MSOP-8 | DGK | BQH |
| | | SO-8 | D | INA200A |
| INA201 | 50V/V | MSOP-8 | DGK | BQJ |
| | | SO-8 | D | INA201A |
| INA202 | 100V/V | MSOP-8 | DGK | BQL |
| | | SO-8 | D | INA202A |

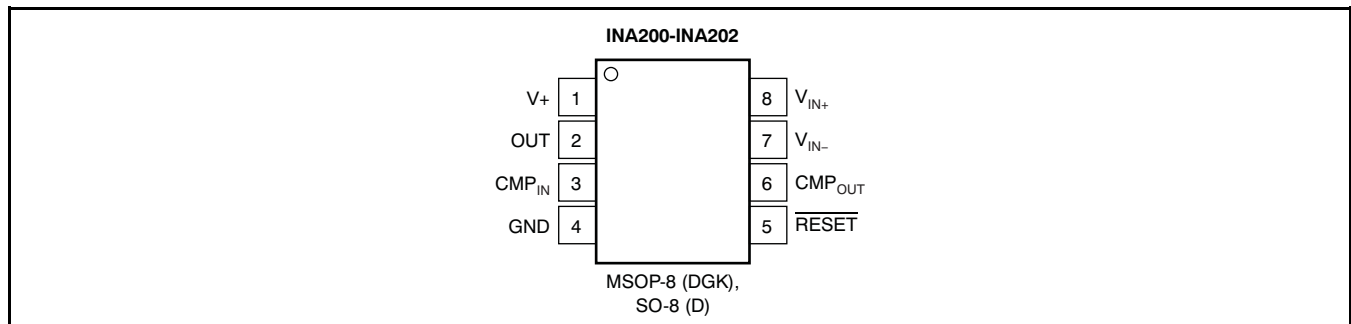
(1) For the most current package and ordering information see the Package Option Addendum at the end of this document, or see the device product folder at www.ti.com.

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

| | VALUE | UNIT | |
|--|----------------------------|------|---|
| Supply Voltage, V+ | 18 | V | |
| Current-Shunt Monitor Analog Inputs, V _{IN+} , V _{IN-} | | | |
| Differential (V _{IN+}) – (V _{IN-}) | –18 to +18 | V | |
| Common Mode ⁽²⁾ | –16 to +80 | V | |
| Comparator Analog Input and Reset Pins ⁽²⁾ | GND – 0.3 to (V+) + 0.3 | V | |
| Analog Output, Out ⁽²⁾ | GND – 0.3 to (V+) + 0.3 | V | |
| Comparator Output, Out Pin ⁽²⁾ | GND – 0.3 to 18 | V | |
| Input Current Into Any Pin ⁽²⁾ | 5 | mA | |
| Operating Temperature | –55 to +150 | °C | |
| Storage Temperature | –65 to +150 | °C | |
| Junction Temperature | +150 | °C | |
| ESD Ratings | Human Body Model (HBM) | 4000 | V |
| | Charged Device Model (CDM) | 1000 | V |

- (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not supported.
- (2) This voltage may exceed the ratings shown if the current at that pin is limited to 5mA.

PIN CONFIGURATIONS



ELECTRICAL CHARACTERISTICS: CURRENT-SHUNT MONITOR
Boldface limits apply over the specified temperature range: $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$.

At $T_A = +25^{\circ}\text{C}$, $V_S = +12\text{V}$, $V_{\text{CM}} = +12\text{V}$, $V_{\text{SENSE}} = 100\text{mV}$, $R_L = 10\text{k}\Omega$ to GND, $R_{\text{PULL-UP}} = 5.1\text{k}\Omega$ connected from CMP_{OUT} to V_S , and $\text{CMP}_{\text{IN}} = \text{GND}$, unless otherwise noted.

| CURRENT-SHUNT MONITOR PARAMETERS | CONDITIONS | INA200, INA201, INA202 | | | UNIT |
|--|---------------------|--|--|---|--------------------------------|
| | | MIN | TYP | MAX | |
| INPUT | | | | | |
| Full-Scale Sense Input Voltage | V_{SENSE} | $V_{\text{SENSE}} = V_{\text{IN+}} - V_{\text{IN-}}$ | 0.15 | $(V_S - 0.25)/\text{Gain}$ | V |
| Common-Mode Input Range | V_{CM} | | -16 | 80 | V |
| Common-Mode Rejection | CMR | $V_{\text{IN+}} = -16\text{V}$ to $+80\text{V}$ | 80 | 100 | dB |
| Over Temperature | | $V_{\text{IN+}} = +12\text{V}$ to $+80\text{V}$ | 100 | 123 | dB |
| Offset Voltage, $\text{RTI}^{(1)}$ | V_{OS} | | ± 0.5 | ± 2.5 | mV |
| +25°C to +125°C | | | | ± 3 | mV |
| -40°C to +25°C | | | | ± 3.5 | mV |
| vs Temperature | dV_{OS}/dT | T_{MIN} to T_{MAX} | 5 | | $\mu\text{V}/^{\circ}\text{C}$ |
| vs Power Supply | PSR | $V_{\text{OUT}} = 2\text{V}$, $V_{\text{IN+}} = +18\text{V}$, 2.7V | 2.5 | 100 | $\mu\text{V}/\text{V}$ |
| Input Bias Current, $V_{\text{IN-}}$ Pin | I_B | | ± 9 | ± 16 | μA |
| OUTPUT ($V_{\text{SENSE}} \geq 20\text{mV}$) | | | | | |
| Gain: | G | | | | |
| INA200 | | | 20 | | V/V |
| INA201 | | | 50 | | V/V |
| INA202 | | | 100 | | V/V |
| Gain Error | | $V_{\text{SENSE}} = 20\text{mV}$ to 100mV | ± 0.2 | ± 1 | % |
| Over Temperature | | $V_{\text{SENSE}} = 20\text{mV}$ to 100mV | | ± 2 | % |
| Total Output Error ⁽²⁾ | | $V_{\text{SENSE}} = 120\text{mV}$, $V_S = +16\text{V}$ | ± 0.75 | ± 2.2 | % |
| Over Temperature | | $V_{\text{SENSE}} = 120\text{mV}$, $V_S = +16\text{V}$ | | ± 3.5 | % |
| Nonlinearity Error ⁽³⁾ | | $V_{\text{SENSE}} = 20\text{mV}$ to 100mV | ± 0.002 | | % |
| Output Impedance | R_O | | 1.5 | | Ω |
| Maximum Capacitive Load | | No Sustained Oscillation | 10 | | nF |
| OUTPUT ($V_{\text{SENSE}} < 20\text{mV}$)⁽⁴⁾ | | | | | |
| INA200, INA201, INA202 | | $-16\text{V} \leq V_{\text{CM}} < 0\text{V}$ | 300 | | mV |
| INA200 | | $0\text{V} \leq V_{\text{CM}} \leq V_S$, $V_S = 5\text{V}$ | | 0.4 | V |
| INA201 | | $0\text{V} \leq V_{\text{CM}} \leq V_S$, $V_S = 5\text{V}$ | | 1 | V |
| INA202 | | $0\text{V} \leq V_{\text{CM}} \leq V_S$, $V_S = 5\text{V}$ | | 2 | V |
| INA200, INA201, INA202 | | $V_S < V_{\text{CM}} \leq 80\text{V}$ | 300 | | mV |
| VOLTAGE OUTPUT⁽⁵⁾ | | | | | |
| Output Swing to the Positive Rail | | $V_{\text{IN-}} = 11\text{V}$, $V_{\text{IN+}} = 12\text{V}$ | $(V_+) - 0.15$ | $(V_+) - 0.25$ | V |
| Output Swing to GND⁽⁶⁾ | | $V_{\text{IN-}} = 0\text{V}$, $V_{\text{IN+}} = -0.5\text{V}$ | $(V_{\text{GND}}) + 0.004$ | $(V_{\text{GND}}) + 0.05$ | V |
| FREQUENCY RESPONSE | | | | | |
| Bandwidth: | BW | | | | |
| INA200 | | $C_{\text{LOAD}} = 5\text{pF}$ | 500 | | kHz |
| INA201 | | $C_{\text{LOAD}} = 5\text{pF}$ | 300 | | kHz |
| INA202 | | $C_{\text{LOAD}} = 5\text{pF}$ | 200 | | kHz |
| Phase Margin | | $C_{\text{LOAD}} < 10\text{nF}$ | 40 | | Degrees |
| Slew Rate | SR | | 1 | | V/ μs |
| Settling Time (1%) | | $V_{\text{SENSE}} = 10\text{mV}_{\text{PP}}$ to 100mV_{PP} , $C_{\text{LOAD}} = 5\text{pF}$ | 2 | | μs |
| NOISE, RTI | | | | | |
| Voltage Noise Density | | | 40 | | $\text{nV}/\sqrt{\text{Hz}}$ |

(1) Offset is extrapolated from measurements of the output at 20mV and 100mV V_{SENSE} .

(2) Total output error includes effects of gain error and V_{OS} .

(3) Linearity is best fit to a straight line.

(4) For details on this region of operation, see the [Accuracy Variations](#) section in the [Applications Information](#).

(5) See Typical Characteristic curve *Output Swing vs Output Current*.

(6) Specified by design.

ELECTRICAL CHARACTERISTICS: COMPARATOR

Boldface limits apply over the specified temperature range: $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$.

At $T_A = +25^\circ\text{C}$, $V_S = +12\text{V}$, $V_{CM} = +12\text{V}$, $V_{SENSE} = 100\text{mV}$, $R_L = 10\text{k}\Omega$ to GND, and $R_{PULL-UP} = 5.1\text{k}\Omega$ connected from CMP_{OUT} to V_S , unless otherwise noted.

| COMPARATOR PARAMETERS | CONDITIONS | INA200, INA201, INA202 | | | UNIT |
|--|--|------------------------|---------------------------|------------|---------------|
| | | MIN | TYP | MAX | |
| OFFSET VOLTAGE | | | | | |
| Threshold | $T_A = +25^\circ\text{C}$ | 590 | 608 | 620 | mV |
| Over Temperature | | 586 | | 625 | mV |
| Hysteresis ⁽¹⁾ | $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$ | | -8 | | mV |
| INPUT BIAS CURRENT⁽²⁾ | | | | | |
| CMP_{IN} Pin | | | 0.005 | 10 | nA |
| vs Temperature | | | | 15 | nA |
| INPUT VOLTAGE RANGE | | | | | |
| CMP_{IN} Pin | | | 0V to $V_S - 1.5\text{V}$ | | V |
| OUTPUT (OPEN-DRAIN) | | | | | |
| Large-Signal Differential Voltage Gain | CMP V_{OUT} 1V to 4V, $R_L \geq 15\text{k}\Omega$ Connected to 5V | | 200 | | V/mV |
| High-Level Leakage Current ⁽³⁾ ⁽⁴⁾ | I_{LKG} $V_{ID} = 0.4\text{V}$, $V_{OH} = V_S$ | | 0.0001 | 1 | μA |
| Low-Level Output Voltage ⁽³⁾ | V_{OL} $V_{ID} = -0.6\text{V}$, $I_{OL} = 2.35\text{mA}$ | | 220 | 300 | mV |
| RESPONSE TIME | | | | | |
| Response Time ⁽⁵⁾ | R_L to 5V, $C_L = 15\text{pF}$, 100mV Input Step with 5mV Overdrive | | 1.3 | | μs |
| RESET | | | | | |
| $\overline{\text{RESET}}$ Threshold ⁽⁶⁾ | | | 1.1 | | V |
| Logic Input Impedance | | | 2 | | M Ω |
| Minimum $\overline{\text{RESET}}$ Pulse Width | | | 1.5 | | μs |
| $\overline{\text{RESET}}$ Propagation Delay | | | 3 | | μs |

- (1) Hysteresis refers to the threshold (the threshold specification applies to a rising edge of a noninverting input) of a falling edge on the noninverting input of the comparator; refer to [Figure 1](#).
- (2) Specified by design.
- (3) V_{ID} refers to the differential voltage at the comparator inputs.
- (4) Open-drain output can be pulled to the range of +2.7V to +18V, regardless of V_S .
- (5) The comparator response time specified is the interval between the input step function and the instant when the output crosses 1.4V.
- (6) The $\overline{\text{RESET}}$ input has an internal 2M Ω (typical) pull-down. Leaving $\overline{\text{RESET}}$ open results in a LOW state, with transparent comparator operation.

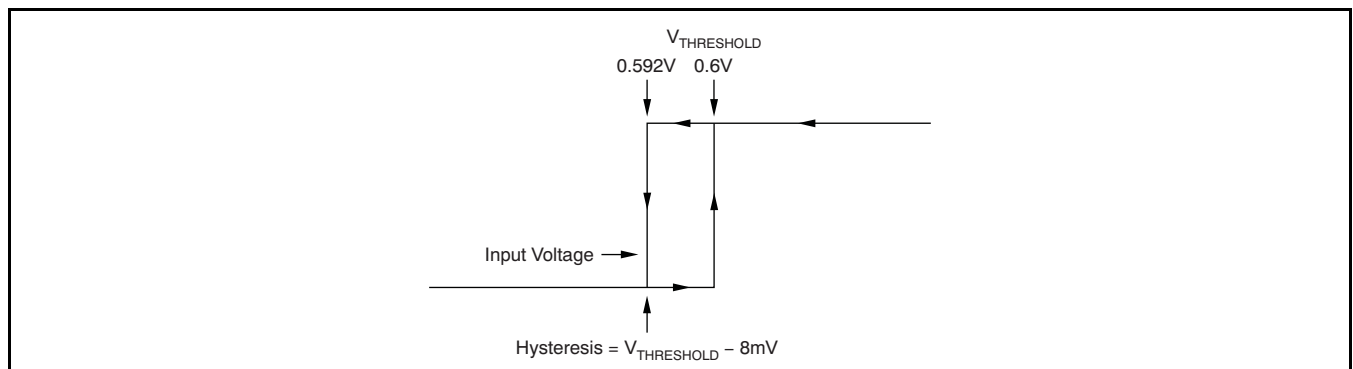


Figure 1. Typical Comparator Hysteresis

ELECTRICAL CHARACTERISTICS: GENERAL

Boldface limits apply over the specified temperature range: $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$.

At $T_A = +25^{\circ}\text{C}$, $V_S = +12\text{V}$, $V_{CM} = +12\text{V}$, $V_{SENSE} = 100\text{mV}$, $R_L = 10\text{k}\Omega$ to GND, $R_{PULL-UP} = 5.1\text{k}\Omega$ connected from CMP_{OUT} to V_S , and $\text{CMP}_{IN} = 1\text{V}$, unless otherwise noted.

| GENERAL PARAMETERS | CONDITIONS | INA200, INA201, INA202 | | | UNIT |
|--|--------------------------|------------------------|------|-------------|-----------------------------|
| | | MIN | TYP | MAX | |
| POWER SUPPLY | | | | | |
| Operating Power Supply | V_S | +2.7 | | +18 | V |
| Quiescent Current | I_Q | | 1350 | 1800 | μA |
| Over Temperature | | | | 1850 | μA |
| Comparator Power-On Reset Threshold ⁽¹⁾ | $V_{SENSE} = 0\text{mV}$ | | 1.5 | | V |
| TEMPERATURE | | | | | |
| Specified Temperature Range | | -40 | | +125 | $^{\circ}\text{C}$ |
| Operating Temperature Range | | -55 | | +150 | $^{\circ}\text{C}$ |
| Storage Temperature Range | | -65 | | +150 | $^{\circ}\text{C}$ |
| Thermal Resistance | θ_{JA} | | | | |
| MSOP-8 Surface-Mount | | | 200 | | $^{\circ}\text{C}/\text{W}$ |
| SO-8 | | | 150 | | $^{\circ}\text{C}/\text{W}$ |

- (1) The INA200, INA201, and INA202 are designed to power-up with the comparator in a defined reset state as long as $\overline{\text{RESET}}$ is open or grounded. The comparator is in reset as long as the power supply is below the voltage shown here. The comparator assumes a state based on the comparator input above this supply voltage. If $\overline{\text{RESET}}$ is high at power-up, the comparator output comes up high and requires a reset to assume a low state, if appropriate.

TYPICAL CHARACTERISTICS

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.

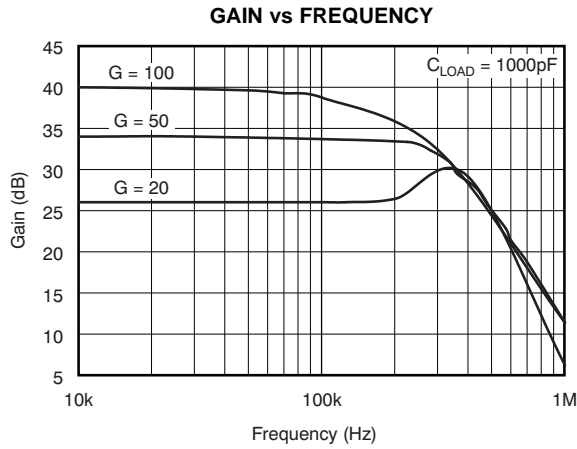


Figure 2.

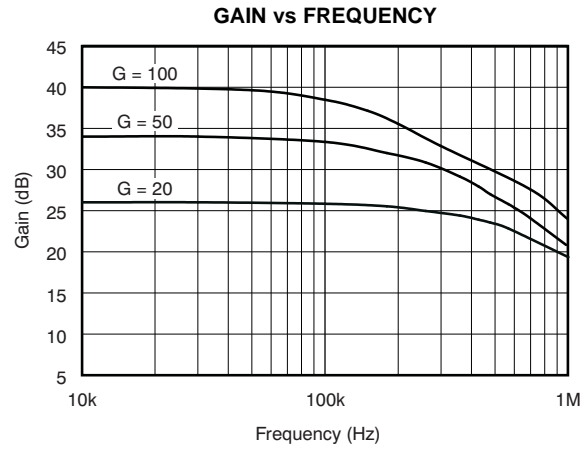


Figure 3.

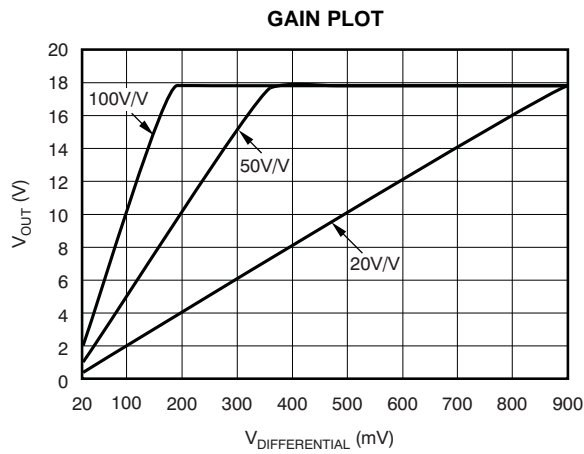


Figure 4.

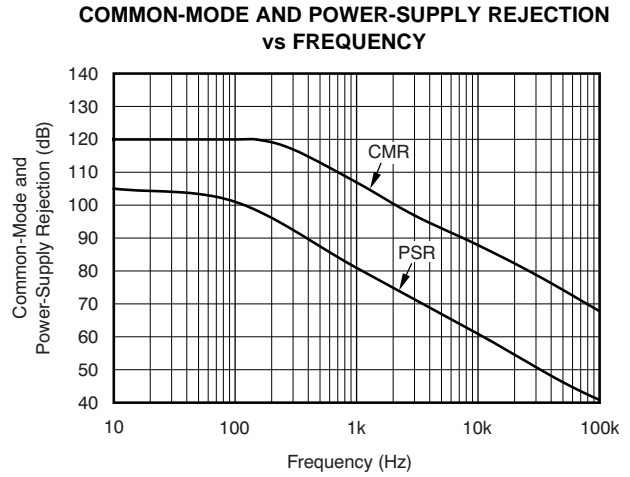


Figure 5.

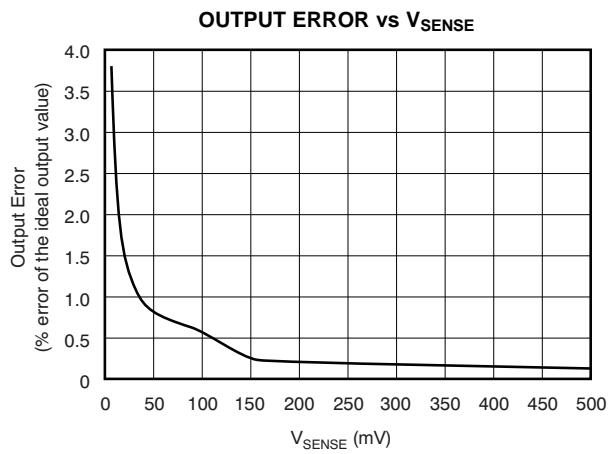


Figure 6.

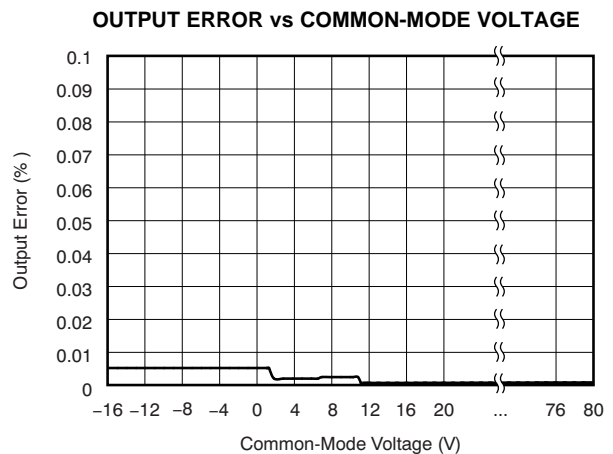


Figure 7.

TYPICAL CHARACTERISTICS (continued)

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.

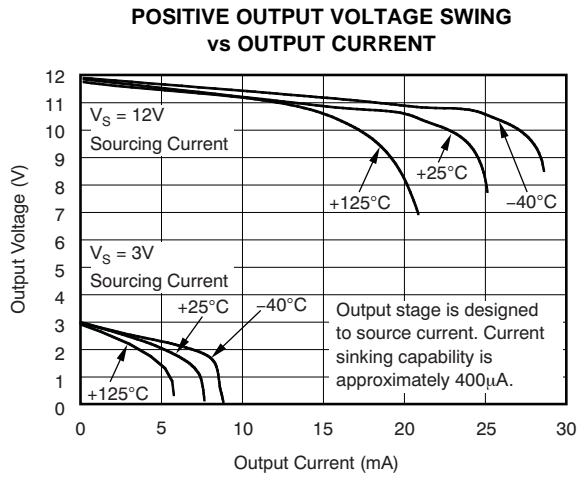


Figure 8.

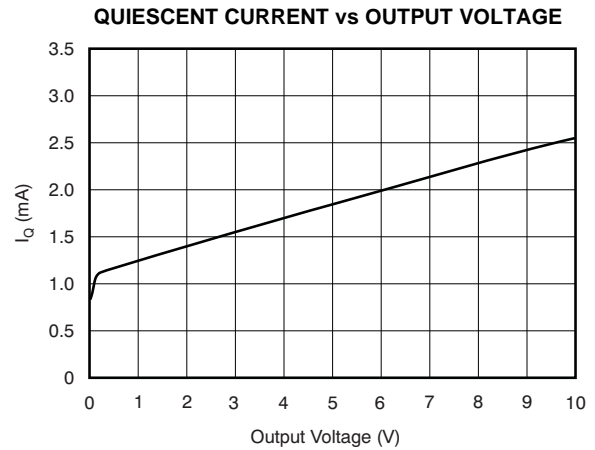


Figure 9.

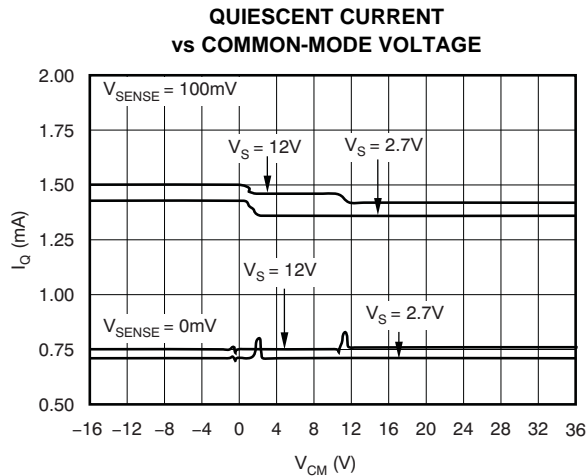


Figure 10.

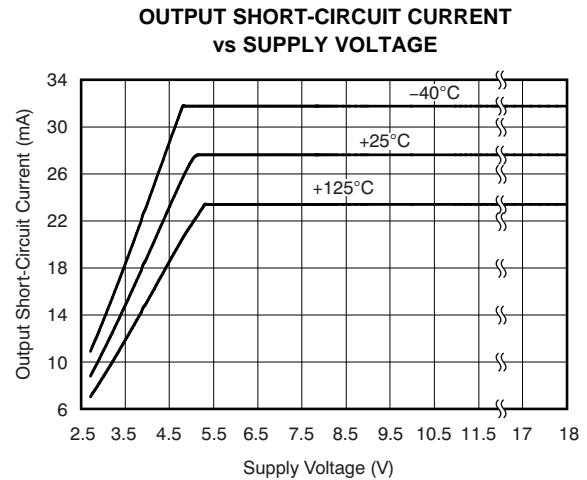


Figure 11.

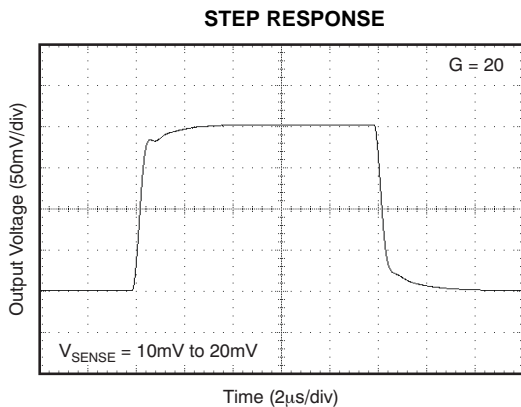


Figure 12.

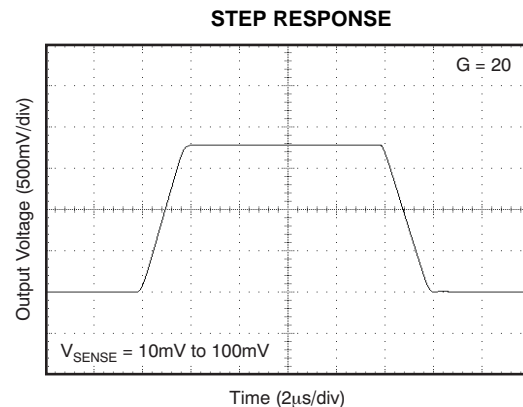


Figure 13.

TYPICAL CHARACTERISTICS (continued)

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.

STEP RESPONSE

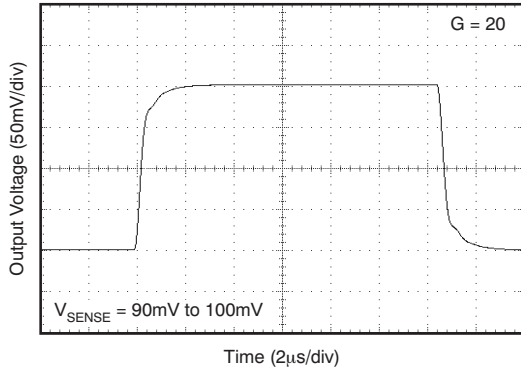


Figure 14.

STEP RESPONSE

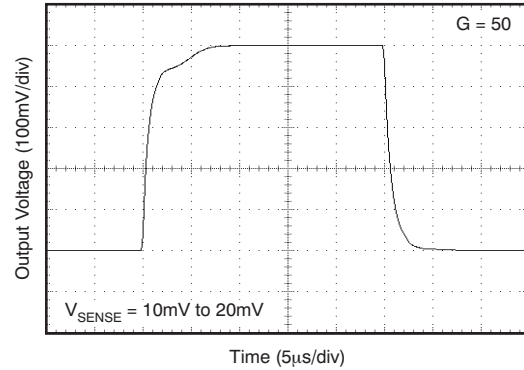


Figure 15.

STEP RESPONSE

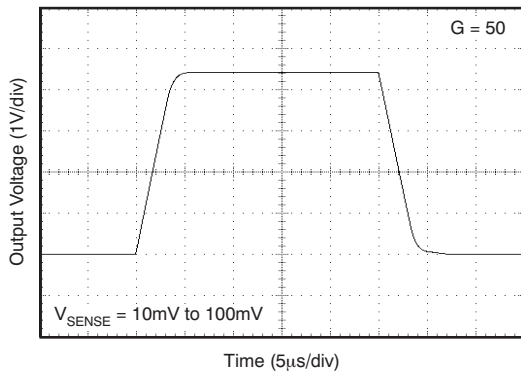


Figure 16.

STEP RESPONSE

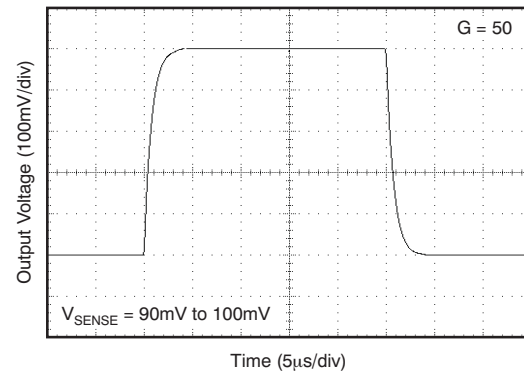


Figure 17.

STEP RESPONSE

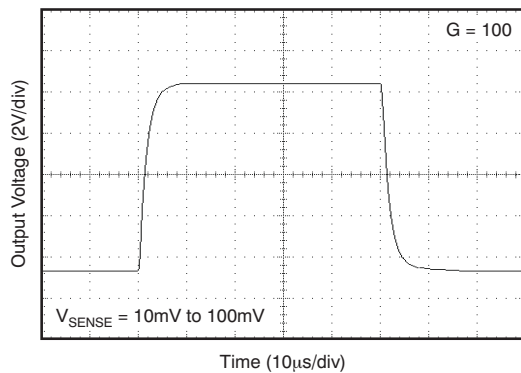


Figure 18.

COMPARATOR V_{OL} vs I_{SINK}

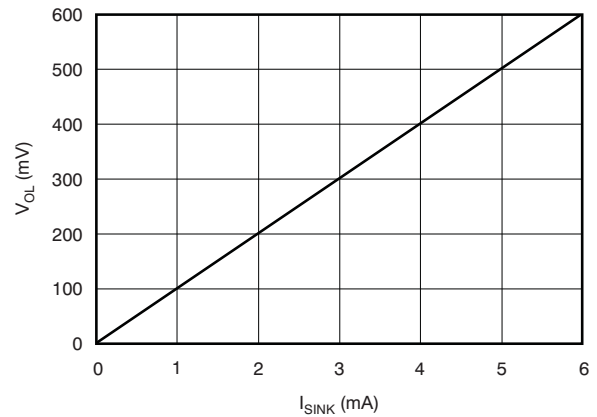


Figure 19.

TYPICAL CHARACTERISTICS (continued)

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.

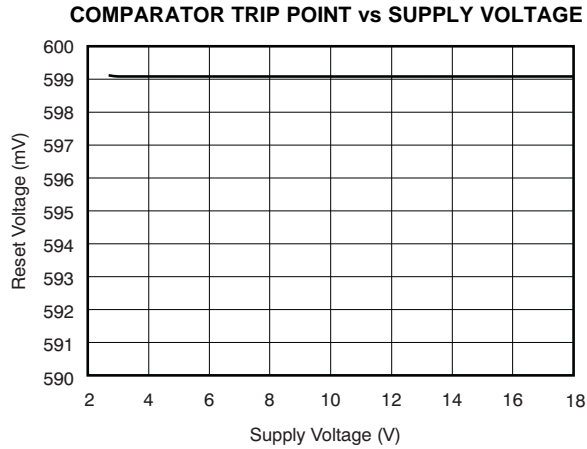


Figure 20.

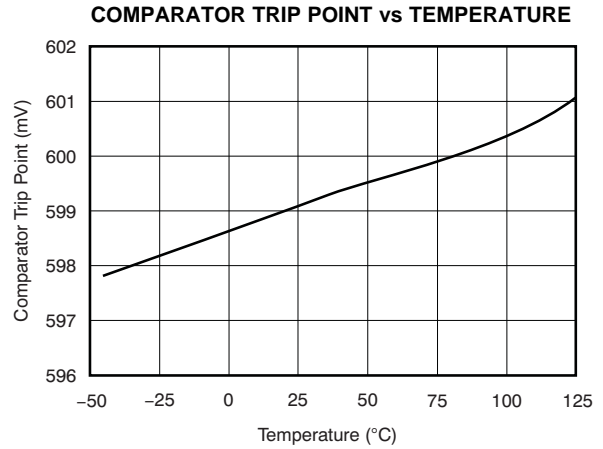


Figure 21.

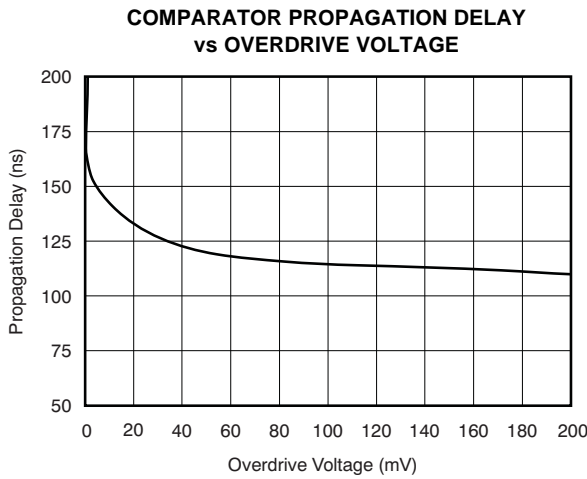


Figure 22.

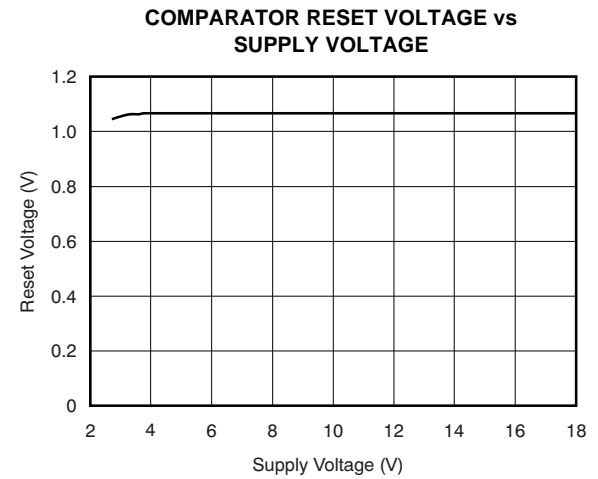


Figure 23.

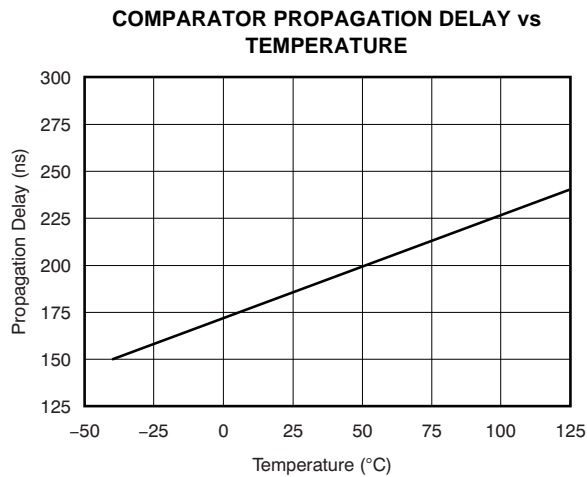


Figure 24.

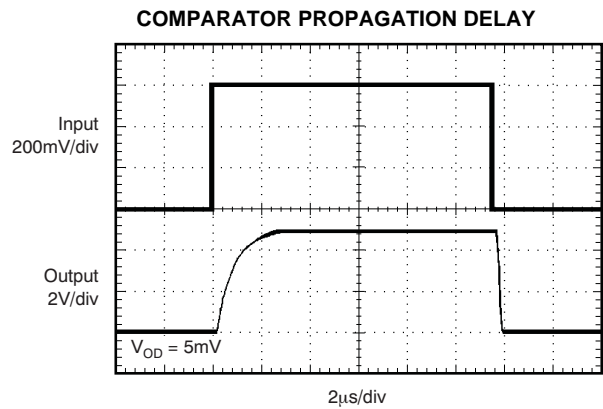


Figure 25.

APPLICATIONS INFORMATION

BASIC CONNECTIONS

Figure 26 shows the basic connections of the INA200, INA201, and INA202. The input pins, V_{IN+} and V_{IN-} , should be connected as closely as possible to the shunt resistor to minimize any resistance in series with the shunt resistance.

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.

POWER SUPPLY

The input circuitry of the INA200, INA201, and INA202 can accurately measure beyond the power-supply voltage, $V+$. For example, the $V+$ power supply can be 5V, whereas the load power-supply voltage is up to +80V. The output voltage range of the OUT terminal, however, is limited by the voltages on the power-supply pin.

ACCURACY VARIATIONS AS A RESULT OF V_{SENSE} AND COMMON-MODE VOLTAGE

The accuracy of the INA200, INA201, and INA202 current shunt monitors is a function of two main variables: V_{SENSE} ($V_{IN+} - V_{IN-}$) and common-mode voltage, V_{CM} , relative to the supply voltage, V_S . V_{CM} is expressed as $(V_{IN+} + V_{IN-})/2$; however, in practice, V_{CM} is seen as the voltage at V_{IN+} because the voltage drop across V_{SENSE} is usually small.

This section addresses the accuracy of these specific operating regions:

- Normal Case 1: $V_{SENSE} \geq 20\text{mV}$, $V_{CM} \geq V_S$
- Normal Case 2: $V_{SENSE} \geq 20\text{mV}$, $V_{CM} < V_S$
- Low V_{SENSE} Case 1: $V_{SENSE} < 20\text{mV}$, $-16\text{V} \leq V_{CM} < 0$
- Low V_{SENSE} Case 2: $V_{SENSE} < 20\text{mV}$, $0\text{V} \leq V_{CM} \leq V_S$
- Low V_{SENSE} Case 3: $V_{SENSE} < 20\text{mV}$, $V_S < V_{CM} \leq 80\text{V}$

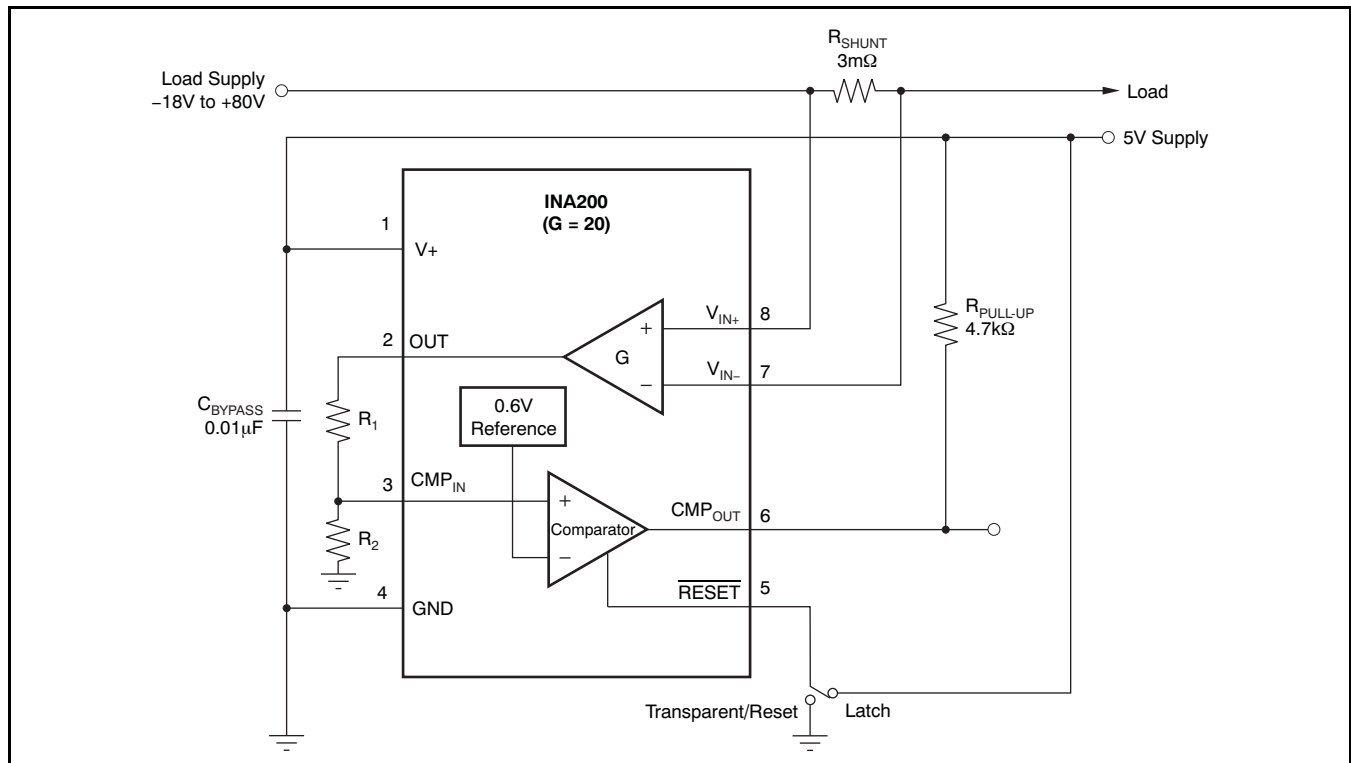


Figure 26. INA200 Basic Connections

Normal Case 1: $V_{SENSE} \geq 20mV$, $V_{CM} \geq V_S$

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 1.

$$G = \frac{V_{OUT1} - V_{OUT2}}{100mV - 20mV} \tag{1}$$

where:

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

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

Then the offset voltage is measured at $V_{SENSE} = 100mV$ and referred to the input (RTI) of the current shunt monitor, as shown in Equation 2.

$$V_{OS\ RTI} \text{ (Referred-To-Input)} = \left[\frac{V_{OUT1}}{G} \right] - 100mV \tag{2}$$

In the [Typical Characteristics](#), the *Output Error vs Common-Mode Voltage* curve (Figure 7) shows the highest accuracy for the this region of operation. In this plot, $V_S = 12V$; for $V_{CM} \geq 12V$, the output error is at its minimum. This case is also used to create the $V_{SENSE} \geq 20mV$ output specifications in the [Electrical Characteristics](#) table.

Normal Case 2: $V_{SENSE} \geq 20mV$, $V_{CM} < V_S$

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 7). As noted, for this graph $V_S = 12V$; for $V_{CM} < 12V$, the Output Error increases as V_{CM} becomes less than 12V, with a typical maximum error of 0.005% at the most negative $V_{CM} = -16V$.

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

Although the INA200 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 INA200, INA201, or INA202, it is important to know what the behavior of the devices will be in these regions.

As V_{SENSE} approaches 0mV, 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 $V_{OUT} = 300mV$ for $V_{SENSE} = 0mV$. As V_{SENSE} approaches 20mV, V_{OUT} returns to the expected output value with accuracy as specified in the [Electrical Characteristics](#). Figure 27 illustrates this effect using the INA202 (Gain = 100).

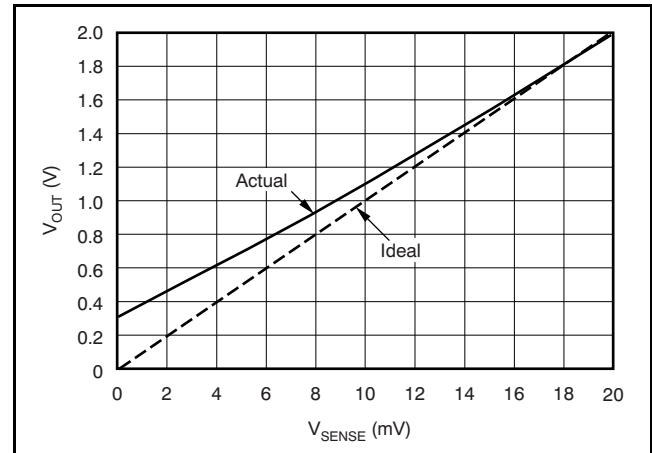


Figure 27. Example for Low V_{SENSE} Cases 1 and 3 (INA202, Gain = 100)

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

This region of operation is the least accurate for the INA200 family. 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 0V. Within this region, as V_{SENSE} approaches 20mV, device operation is closer to that described by Normal Case 2. Figure 28 illustrates this behavior for the INA202. The V_{OUT} maximum peak for this case is tested by maintaining a constant V_S , setting $V_{SENSE} = 0mV$ and sweeping V_{CM} from 0V 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.

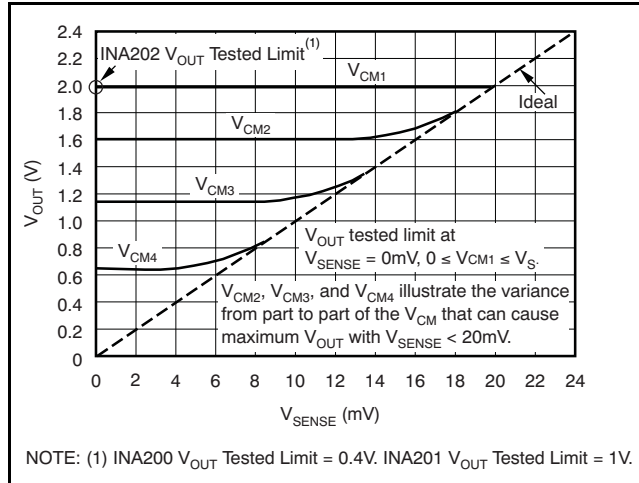


Figure 28. Example for Low V_{SENSE} Case 2 (INA202, Gain = 100)

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 50mV to 100mV. Maximum input voltage for accurate measurements is 500mV.

TRANSIENT PROTECTION

The $-16V$ to $+80V$ common-mode range of the INA200, INA201, and INA202 is ideal for withstanding automotive fault conditions ranging from 12V battery reversal up to $+80V$ transients, since no additional protective components are needed up to those levels. In the event that the INA200, INA201, and INA202 are exposed to transients on the inputs in excess of their ratings, then external transient absorption with semiconductor transient absorbers (such as zeners) 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 INA200, INA201, and INA202 to be exposed to transients greater than $+80V$ (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 INA200, INA201, and INA202 do not lend themselves to using external resistors in

series with the inputs since 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 INA200, INA201, and INA202 inputs with two equal resistors on each input.)

OUTPUT VOLTAGE RANGE

The output of the INA200, INA201, and INA202 is accurate within the output voltage swing range set by the power supply pin, V_+ . This performance is best illustrated when using the INA202 (a gain of 100 version), where a 100mV full-scale input from the shunt resistor requires an output voltage swing of $+10V$, and a power-supply voltage sufficient to achieve $+10V$ on the output.

INPUT FILTERING

An obvious and straightforward location for filtering is at the output of the INA200, INA201, and INA202 series; 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 INA200, INA201, and INA202, which is complicated by the internal $5k\Omega + 30\%$ input impedance; this is illustrated in Figure 29. 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 3:

$$\text{Gain Error \%} = 100 - \left[100 \times \frac{5k\Omega}{5k\Omega + R_{FILT}} \right] \quad (3)$$

Total effect on gain error can be calculated by replacing the $5k\Omega$ term with $5k\Omega - 30\%$ (or $3.5k\Omega$) or $5k\Omega + 30\%$ (or $6.5k\Omega$). The tolerance extremes of R_{FILT} can also be inserted into the equation. If a pair of 100Ω 1% resistors are used on the inputs, the initial gain error will be 1.96%. Worst-case tolerance conditions will always occur at the lower excursion of the internal $5k\Omega$ resistor ($3.5k\Omega$), and the higher excursion of $R_{FILT} - 3\%$ in this case.

Note that the specified accuracy of the INA200, INA201, and INA202 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.

COMPARATOR

The INA200, INA201, and INA202 devices incorporate an open-drain comparator. This comparator typically has 2mV of offset and a $1.3\mu s$ (typical) response time. The output of the comparator latches and is reset through the $RESET$ pin; see Figure 30.

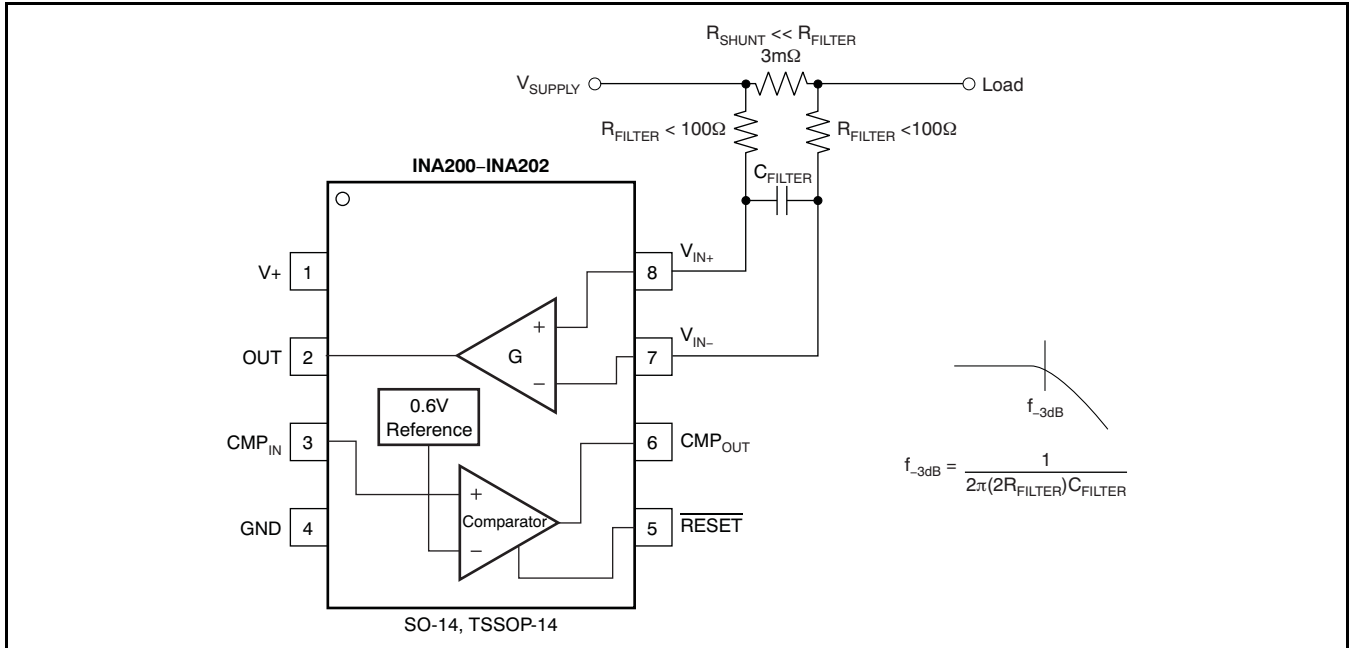


Figure 29. Input Filter (Gain Error—1.5% to -2.2%)

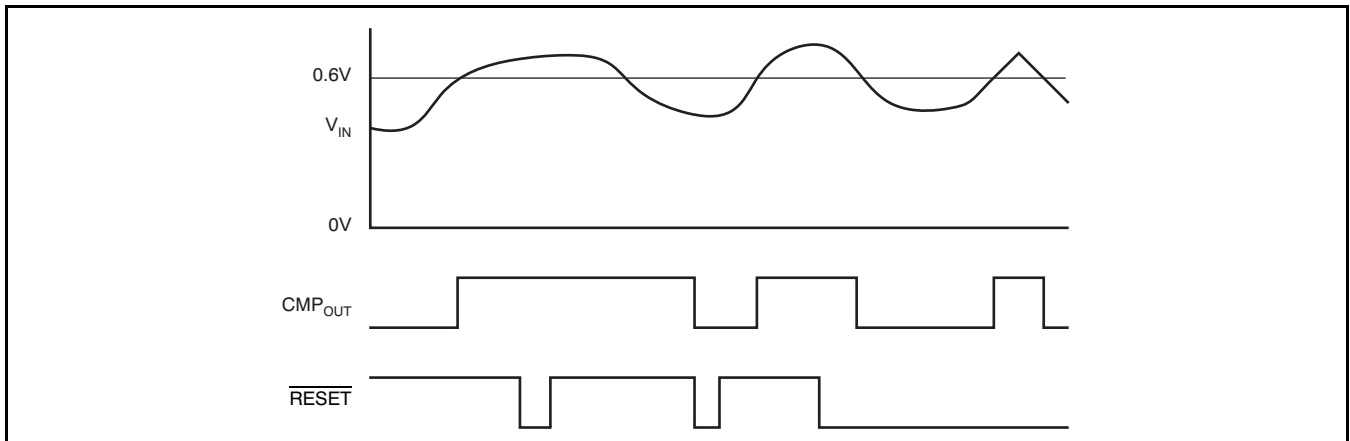


Figure 30. Comparator Latching Capability

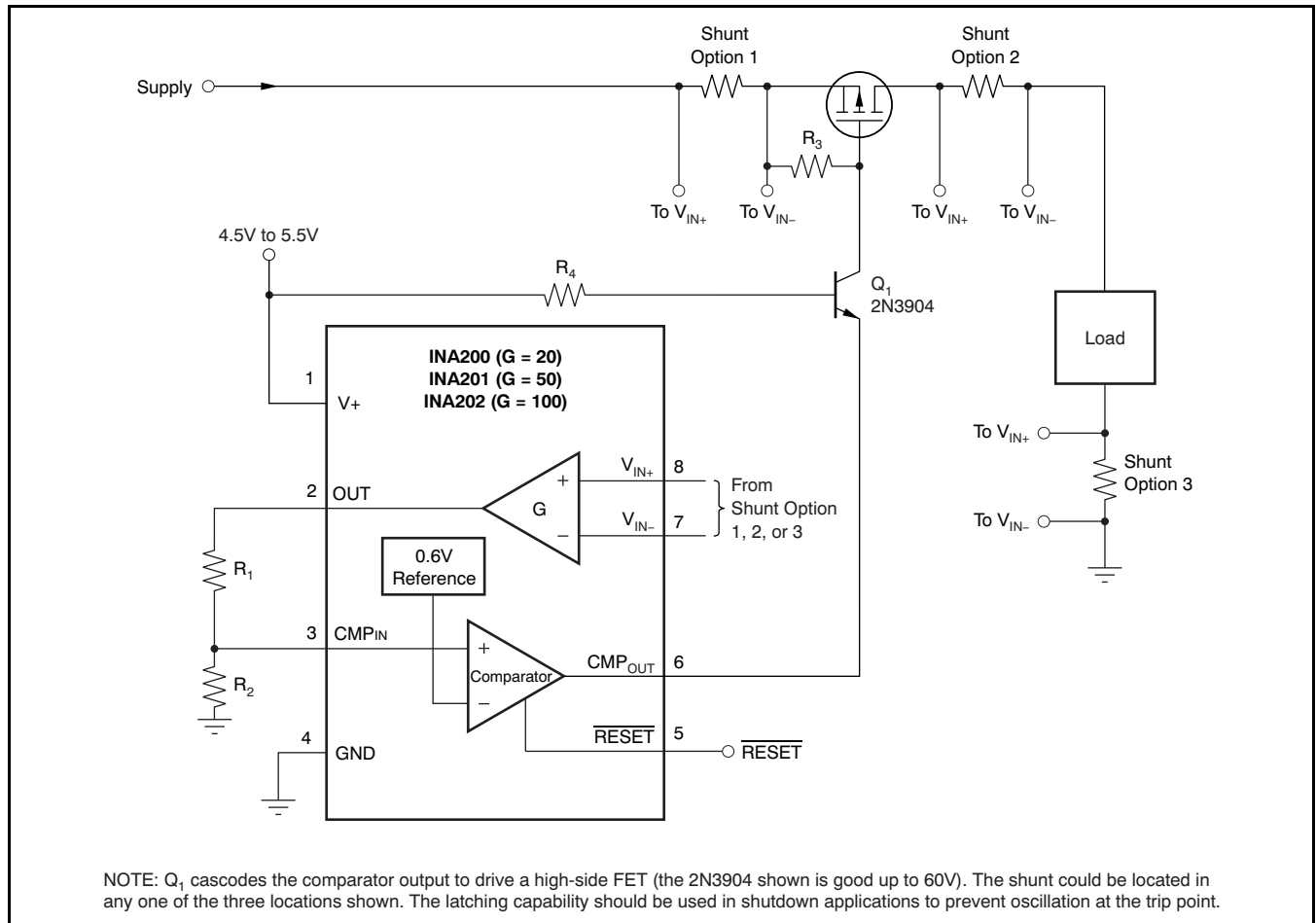


Figure 31. High-Side Switch Over-Current Shutdown

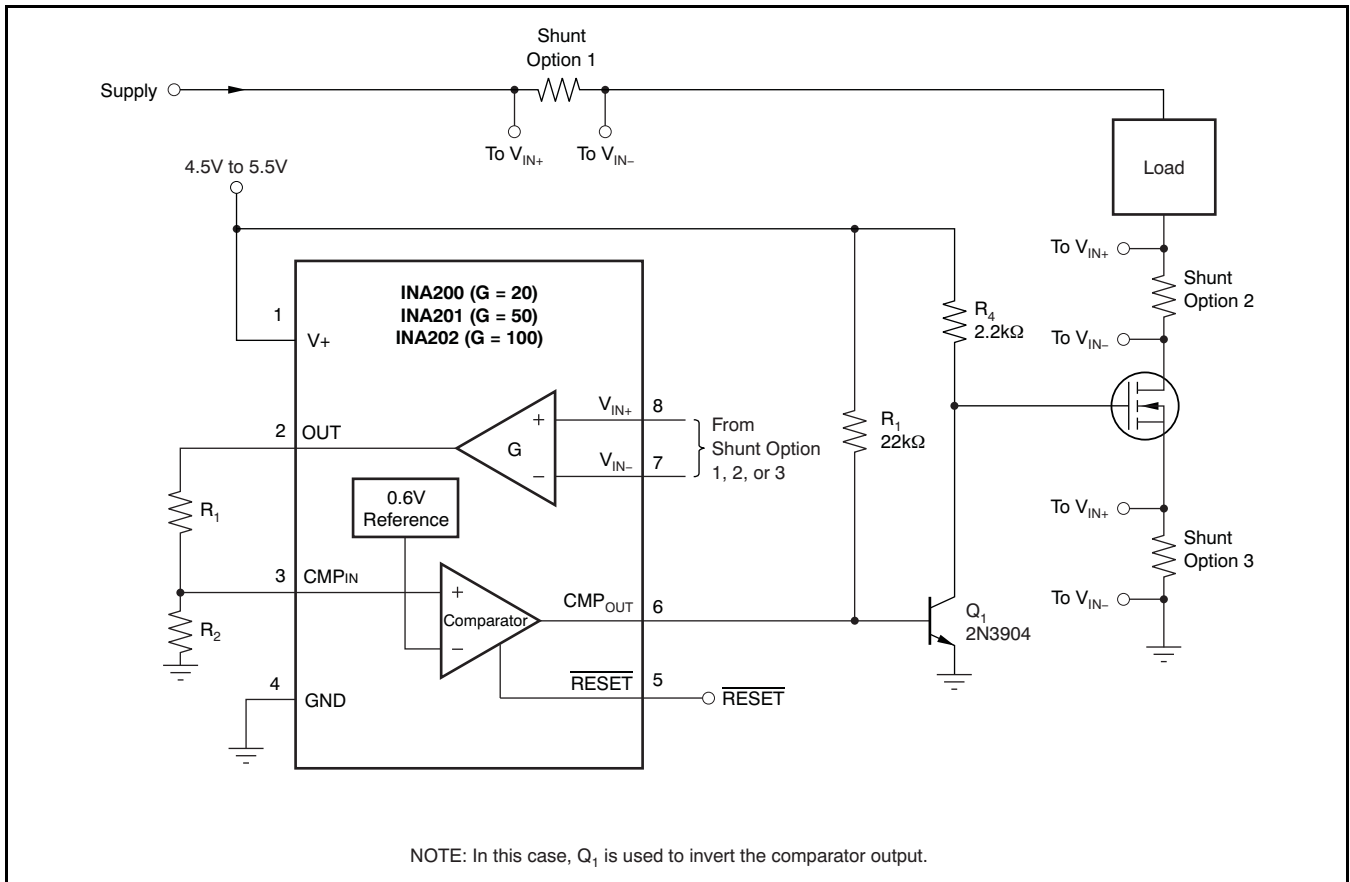


Figure 32. Low-Side Switch Over-Current Shutdown

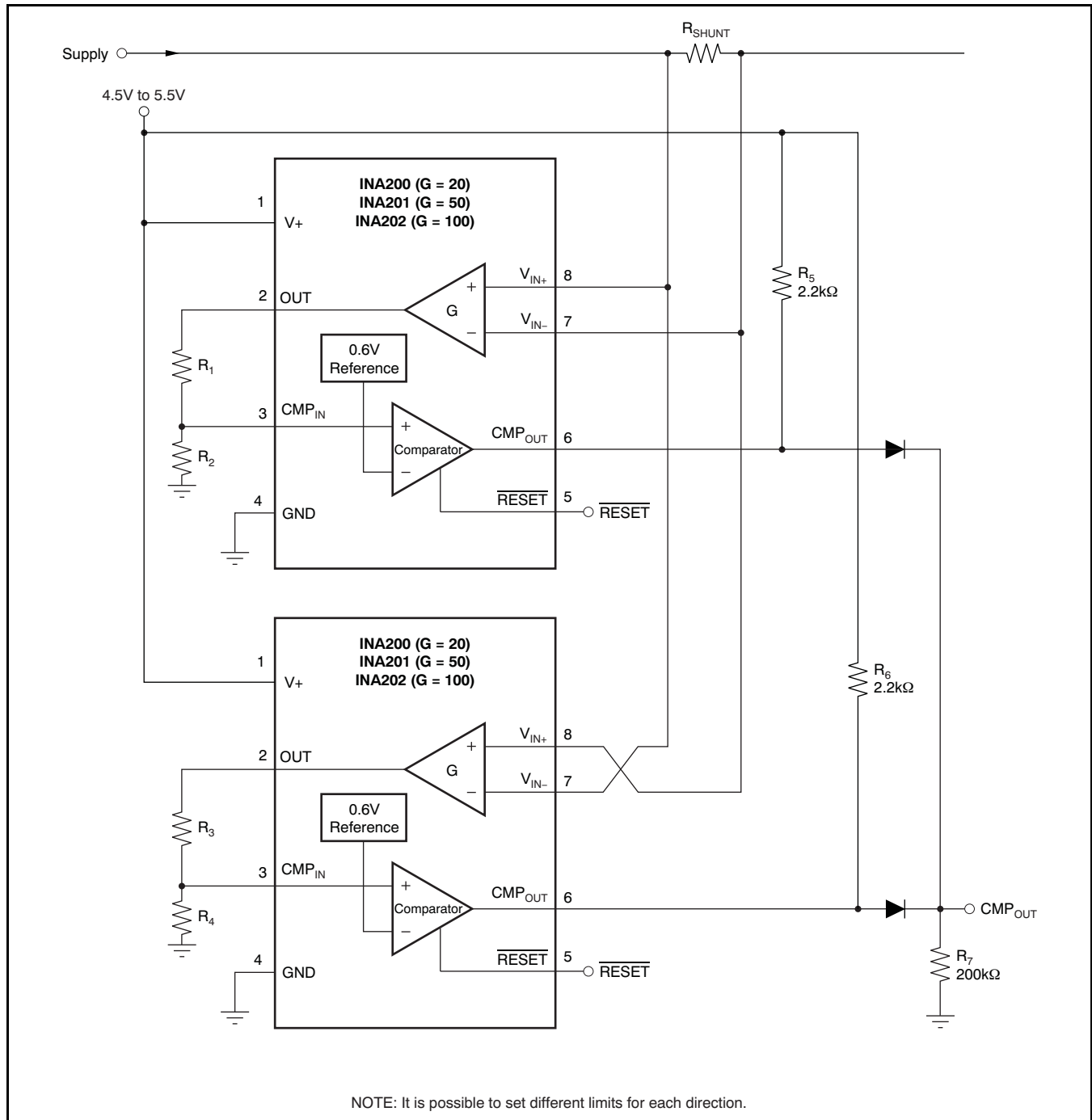


Figure 33. Bidirectional Over-Current Comparator

REVISION HISTORY

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Revision B (October, 2007) to Revision C | Page |
|--|-------------|
| • Changed title of data sheet | 1 |
| • Updated document format to current standards | 1 |
| • Revised front-page figure | 1 |

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) | Samples (Requires Login) |
|------------------|---------------|--------------|--------------------|------|-------------|----------------------------|------------------|----------------------|-----------------------------|
| INA200AID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA200AIDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA200AIDGKR | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | |
| INA200AIDGKRG4 | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | |
| INA200AIDGKT | ACTIVE | VSSOP | DGK | 8 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | |
| INA200AIDGKTG4 | ACTIVE | VSSOP | DGK | 8 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | |
| INA200AIDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA200AIDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA201AID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA201AIDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA201AIDGKR | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA201AIDGKRG4 | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA201AIDGKT | ACTIVE | VSSOP | DGK | 8 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA201AIDGKTG4 | ACTIVE | VSSOP | DGK | 8 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA201AIDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA201AIDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA202AID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) | Samples (Requires Login) |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|------------------|----------------------|-----------------------------|
| INA202AIDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA202AIDGKR | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA202AIDGKRG4 | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA202AIDGKT | ACTIVE | VSSOP | DGK | 8 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA202AIDGKTG4 | ACTIVE | VSSOP | DGK | 8 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA202AIDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| INA202AIDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |

(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.

OBSELETE: TI has discontinued the production of the device.

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

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

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

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

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

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

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.

OTHER QUALIFIED VERSIONS OF INA200, INA201, INA202 :

- Automotive: [INA200-Q1](#), [INA201-Q1](#), [INA202-Q1](#)

NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

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 |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| INA200AIDGKR | VSSOP | DGK | 8 | 2500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| INA200AIDGKT | VSSOP | DGK | 8 | 250 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| INA200AIDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| INA201AIDGKR | VSSOP | DGK | 8 | 2500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| INA201AIDGKT | VSSOP | DGK | 8 | 250 | 180.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| INA201AIDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| INA202AIDGKR | VSSOP | DGK | 8 | 2500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| INA202AIDGKT | VSSOP | DGK | 8 | 250 | 180.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| INA202AIDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| INA200AIDGKR | VSSOP | DGK | 8 | 2500 | 366.0 | 364.0 | 50.0 |
| INA200AIDGKT | VSSOP | DGK | 8 | 250 | 366.0 | 364.0 | 50.0 |
| INA200AIDR | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| INA201AIDGKR | VSSOP | DGK | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| INA201AIDGKT | VSSOP | DGK | 8 | 250 | 210.0 | 185.0 | 35.0 |
| INA201AIDR | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| INA202AIDGKR | VSSOP | DGK | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| INA202AIDGKT | VSSOP | DGK | 8 | 250 | 210.0 | 185.0 | 35.0 |
| INA202AIDR | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 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.

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



- 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.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

| | |
|------------------------------|--|
| Audio | www.ti.com/audio |
| Amplifiers | amplifier.ti.com |
| Data Converters | dataconverter.ti.com |
| DLP® Products | www.dlp.com |
| DSP | dsp.ti.com |
| Clocks and Timers | www.ti.com/clocks |
| Interface | interface.ti.com |
| Logic | logic.ti.com |
| Power Mgmt | power.ti.com |
| Microcontrollers | microcontroller.ti.com |
| RFID | www.ti-rfid.com |
| OMAP Applications Processors | www.ti.com/omap |
| Wireless Connectivity | www.ti.com/wirelessconnectivity |

Applications

| | |
|-------------------------------|--|
| Automotive and Transportation | www.ti.com/automotive |
| Communications and Telecom | www.ti.com/communications |
| Computers and Peripherals | www.ti.com/computers |
| Consumer Electronics | www.ti.com/consumer-apps |
| Energy and Lighting | www.ti.com/energy |
| Industrial | www.ti.com/industrial |
| Medical | www.ti.com/medical |
| Security | www.ti.com/security |
| Space, Avionics and Defense | www.ti.com/space-avionics-defense |
| Video and Imaging | www.ti.com/video |

TI E2E Community

e2e.ti.com