CURRENT SHUNT MONITORS
–16-V to +80-V Common-Mode Range

FEATURES

- **Qualified for Automotive Applications**
- **Wide Common-Mode Voltage: –16 V to +80 V**
- **Low Error: 3.0% Over Temperature (Max)**
- **Bandwidth: Up to 500 kHz**
- **Three Transfer Functions Available: 20 V/V, 50 V/V, and 100 V/V**
- **Complete Current-Sense Solution**

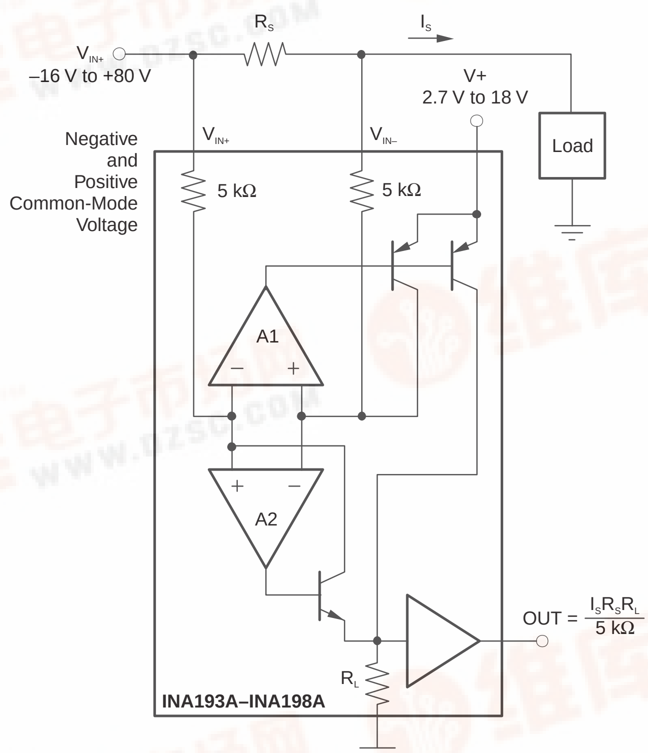
APPLICATIONS

- **Welding Equipment**
- **Notebook Computers**
- **Cell Phones**
- **Telecom Equipment**
- **Automotive**
- **Power Management**
- **Battery Chargers**

DESCRIPTION

The INA193A–INA198A family of current shunt monitors with voltage output can sense drops across shunts at common-mode voltages from –16 V to +80 V, independent of the INA19xA 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 INA193A–INA195A provide identical functions but alternative pin configurations to the INA196A–INA198A, respectively.

The INA193A–INA198A operate from a single 2.7-V to 18-V supply. They are specified over the extended operating temperature range (–40°C to 125°C), and are offered in a space-saving SOT-23 package.



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.

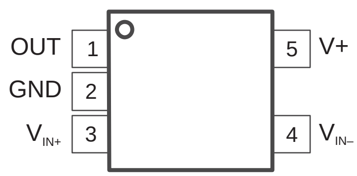
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

ORDERING INFORMATION(1)

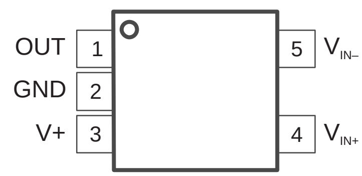
T_A	PACKAGE(2)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 125°C	SOT-23 – DBV	Reel of 3000	INA193AQDBVRQ1	BOG
			INA194AQDBVRQ1	BOH
			INA195AQDBVRQ1	BOI
			INA196AQDBVRQ1	BOJ
			INA197AQDBVRQ1	BOK
			INA198AQDBVRQ1	BOL

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the website at www.ti.com.
(2) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

INA193A
INA194A
INA195A
DBV PACKAGE
(TOP VIEW)



INA196A
INA197A
INA198A
DBV PACKAGE
(TOP VIEW)



ABSOLUTE MAXIMUM RATINGS(1)

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

		MIN	MAX	UNIT
Supply voltage			18	V
Differential input voltage range, analog inputs (V_{IN+} – $V_{IN–}$)		–18	18	V
Common-mode voltage range(2)		–16	80	V
Analog output voltage range(2)	OUT	GND – 0.3	(V+) + 0.3	V
Input current into any pin(2)			5	mA
Storage temperature range		–65	150	°C
Junction temperature			150	°C
ESD qualification ratings	Human-Body Model		4000	V
	Machine Model		200	
	Charged-Device Model		1000	

(1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. 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 5 mA.

ELECTRICAL CHARACTERISTICS

V_S = 12 V, V_{IN+} = 12 V, V_{SENSE} = 100 mV (unless otherwise noted)
Full range T_A = –40°C to 125°C

PARAMETER		TEST CONDITIONS		T_A	MIN	TYP	MAX	UNIT
INPUT								
V_{SENSE}	Full-scale input voltage	$V_{SENSE} = V_{IN+} - V_{IN-}$		25°C		0.15	(V_S – 0.2)/ Gain	V
VCM	Common-mode input			Full range	–16		80	V
CMR	Common-mode rejection	V_{IN+} = −16 V to +80 V		25°C	80	94		dB
		V_{IN+} = 12 V to 80 V		Full range	100	120		
V_{OS}	Offset voltage, RTI			25°C		±0.5	2	mV
				Full range		0.5	3	
dV_{OS}/dT	Offset voltage vs temperature			Full range		2.5		µV/°C
PSR	Offset voltage vs power supply	V_S = 2.7 V to 18 V, V_{IN+} = 18 V		Full range		5	100	µV/V
I_B	Input bias current	V_{IN-} pin		Full range		±8	±23	µA
OUTPUT (V_{SENSE} ≥ 20 mV)								
G	Gain	INA193A, INA196A		25°C		20		V/V
		INA194A, INA197A				50		
		INA195A, INA198A				100		
	Gain error	V_{SENSE} = 20 mV to 100 mV		25°C		±0.2	±1	%
				Full range			±2	
	Total output error(1)			25°C		±0.75	±2.2	%
				Full range		±1	±3	
	Nonlinearity error	V_{SENSE} = 20 mV to 100 mV		25°C		±0.002	±0.1	%
R_O	Output impedance			25°C		1.5		Ω
	Maximum capacitive load	No sustained oscillation		25°C		10		nF
OUTPUT (V_{SENSE} < 20 mV) (2)								
V_{OUT}	Output voltage	All devices	–16 V ≤ V_{CM} < 0	25°C		300		mV
			V_S < V_{CM} ≤ 80 V			300		
		INA193A, INA196A	0 V ≤ V_{CM} ≤ V_S, V_S = 5 V				0.4	V
		INA194A, INA197A					1	
		INA195A, INA198A					2	
VOLTAGE OUTPUT(3)								
	Swing to V+ power-supply rail	R_L = 100 kΩ to GND		Full range		V+ – 0.1	V+ – 0.2	V
	Swing to GND(4)	R_L = 100 kΩ to GND		Full range		V_{GND} + 3	V_{GND} + 50	mV

(1) Total output error includes effects of gain error and V_{OS}.
(2) For details on this region of operation, see *Accuracy Variations as a Result of V_{SENSE} and Common-Mode Voltage* in *Applications Information*.
(3) See Typical Characteristics curve Output Swing vs Output Current.
(4) Specified by design

ELECTRICAL CHARACTERISTICS (continued)

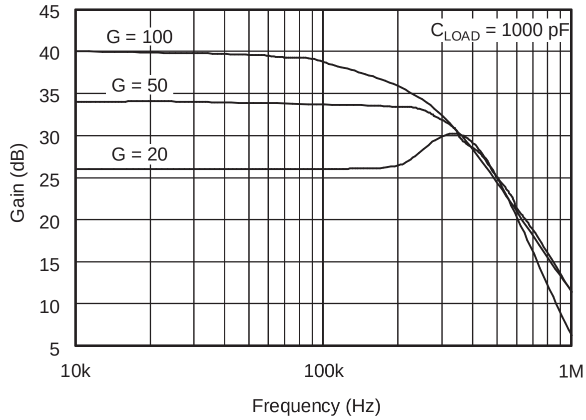
V_S = 12 V, V_{IN+} = 12 V, V_{SENSE} = 100 mV (unless otherwise noted)
Full range T_A = –40°C to 125°C

PARAMETER		TEST CONDITIONS		T_A	MIN	TYP	MAX	UNIT
FREQUENCY RESPONSE								
BW	Bandwidth	INA193A, INA196A	C_{LOAD} = 5 pF	25°C		500		kHz
BW	Bandwidth	INA194A, INA197A	C_{LOAD} = 5 pF	25°C		300		kHz
BW	Bandwidth	INA195A, INA198A	C_{LOAD} = 5 pF	25°C		200		kHz
	Phase margin	C_{LOAD} < 10 nF		25°C		40		°
SR	Slew rate					1		V/µs
t_s	Settling time (1%)	V_{SENSE} = 10 mV to 100 mV_{PP}, C_{LOAD} = 5 pF		25°C		2		µs
NOISE, RTI								
	Voltage noise density			25°C		40		nV/√Hz
POWER SUPPLY								
V_S	Operating voltage			Full range	2.7		18	V
I_Q	Quiescent current	V_{OUT} = 2 V		Full range		700	1250	µA
I_Q	Quiescent current	INA193A, INA194A, INA196A, INA197A	V_{SENSE} = 0 mV	Full range		370	950	µA
I_Q	Quiescent current	INA195A, INA198A	V_{SENSE} = 0 mV	Full range		370	1050	µA
TEMPERATURE RANGE								
	Operating temperature				–40		125	°C
	Storage temperature				–65		150	°C
θ_{JA}	Thermal resistance					200		°C/W

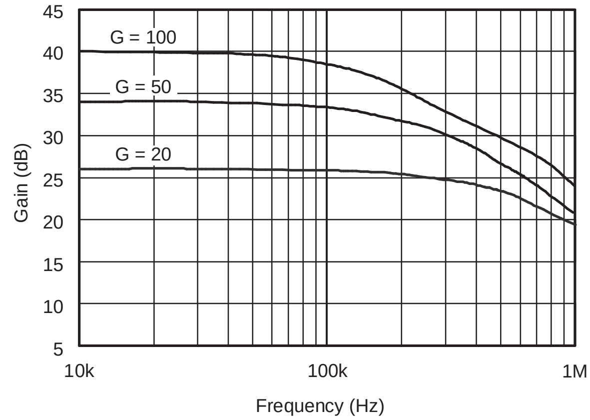
TYPICAL CHARACTERISTICS

T_A = 25°C, V_S = 12 V, V_{IN+} = 12 V, and V_{SENSE} = 100 mV (unless otherwise noted)

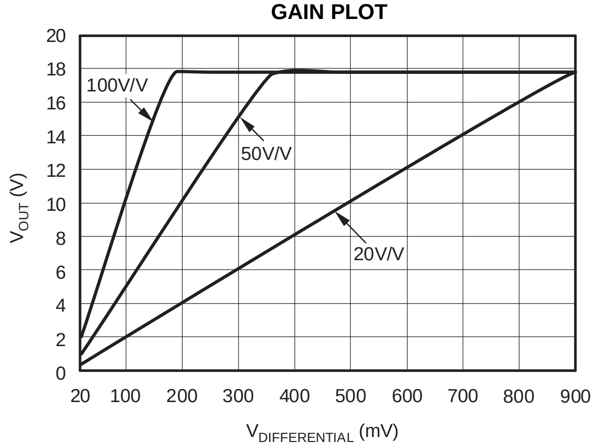
GAIN vs FREQUENCY



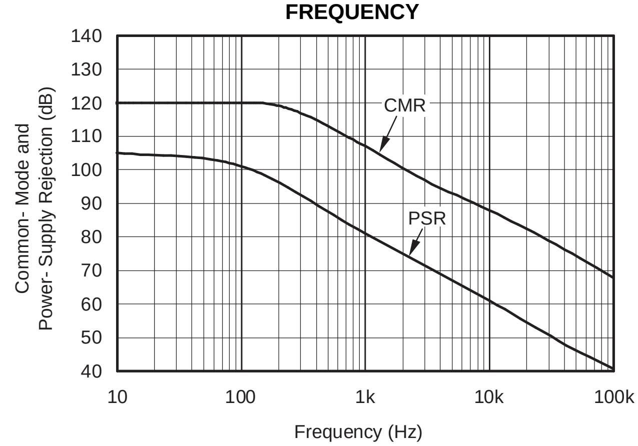
GAIN vs FREQUENCY



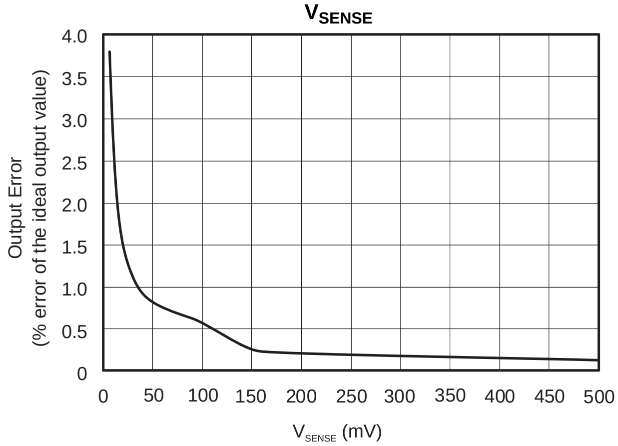
GAIN PLOT



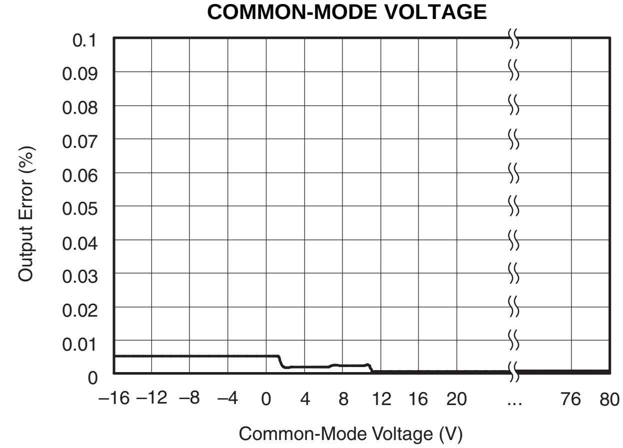
COMMON-MODE and POWER-SUPPLY REJECTION vs FREQUENCY



OUTPUT ERROR vs V_{SENSE}



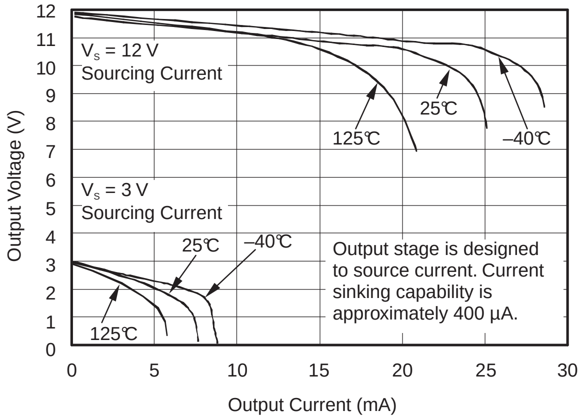
OUTPUT ERROR vs COMMON-MODE VOLTAGE



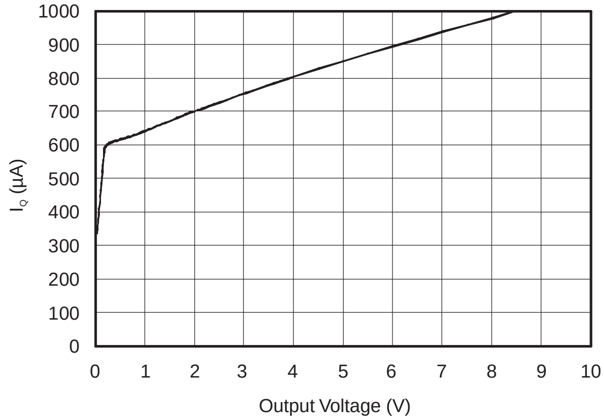
TYPICAL CHARACTERISTICS (continued)

T_A = 25°C, V_S = 12 V, V_{IN+} = 12 V, and V_{SENSE} = 100 mV (unless otherwise noted)

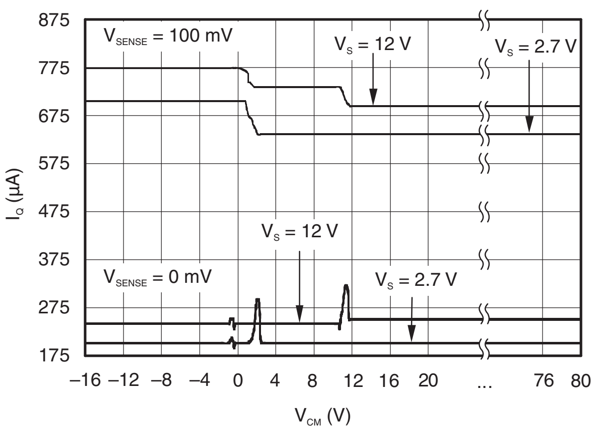
POSITIVE OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



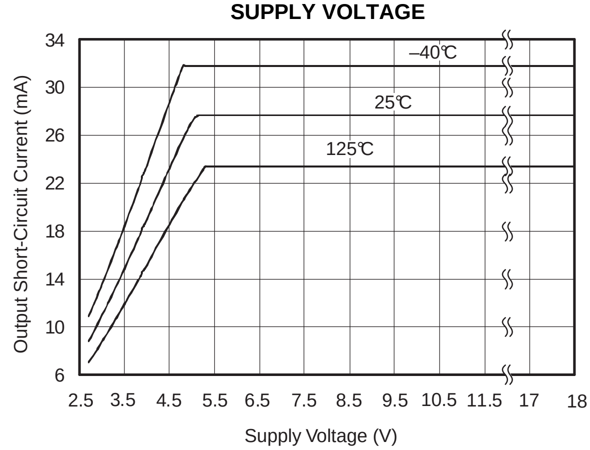
QUIESCENT CURRENT vs OUTPUT VOLTAGE



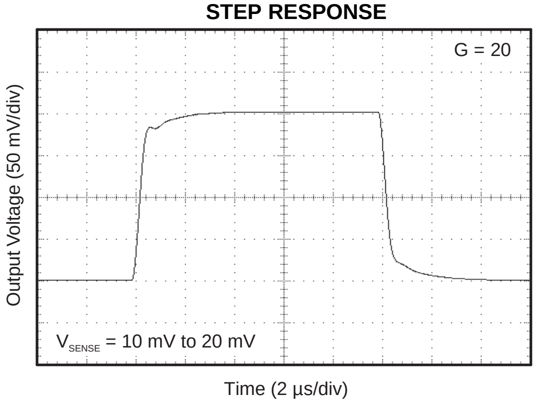
QUIESCENT CURRENT vs COMMON-MODE VOLTAGE



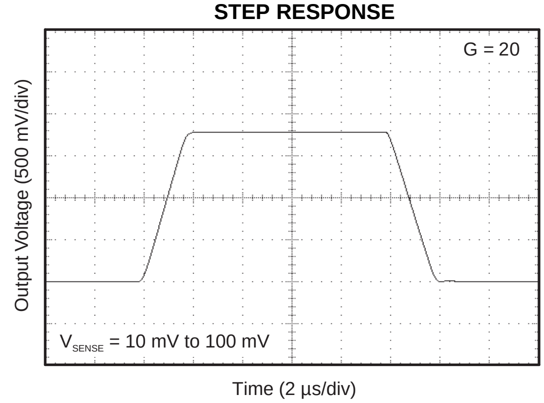
OUTPUT SHORT-CIRCUIT CURRENT vs SUPPLY VOLTAGE



STEP RESPONSE



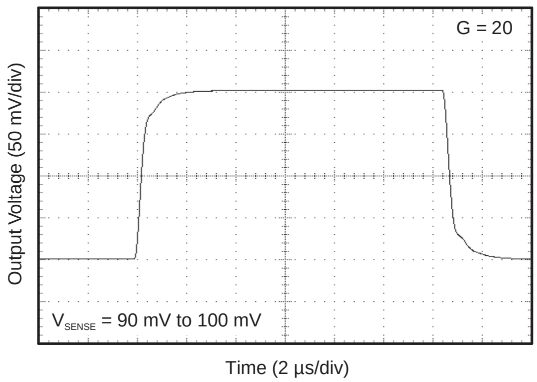
STEP RESPONSE



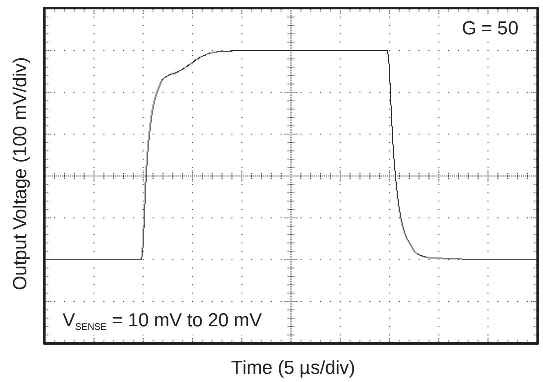
TYPICAL CHARACTERISTICS (continued)

T_A = 25°C, V_S = 12 V, V_{IN+} = 12 V, and V_{SENSE} = 100 mV (unless otherwise noted)

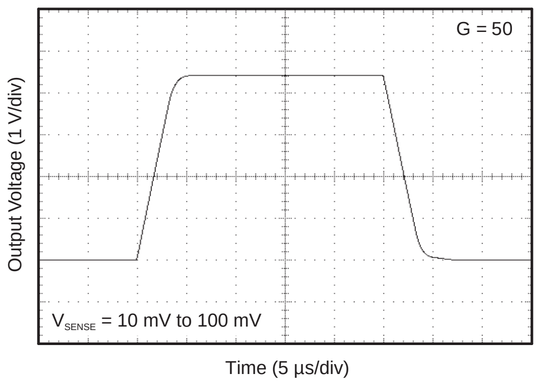
STEP RESPONSE



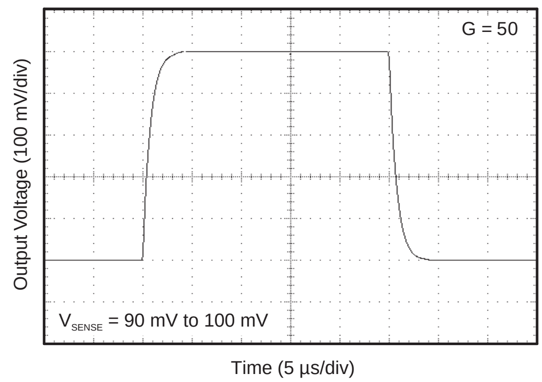
STEP RESPONSE



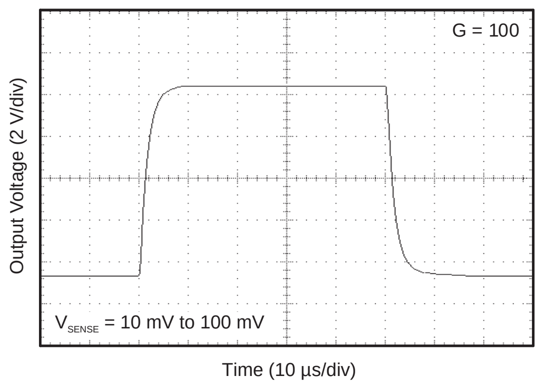
STEP RESPONSE



STEP RESPONSE



STEP RESPONSE



APPLICATION INFORMATION

Basic Connection

Figure 1 shows the basic connection of the INA19xA. 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.

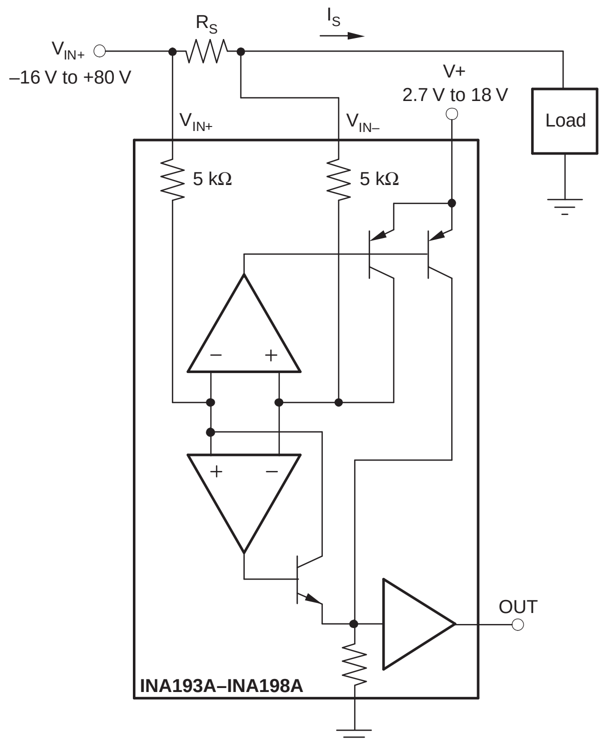


Figure 1. INA19xA Basic Connection

Power Supply

The input circuitry of the INA19xA 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.

Accuracy Variations as a Result of V_{SENSE} and Common-Mode Voltage

The accuracy of the INA193A–INA198A 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: $V_{SENSE} \geq 20$ mV, $V_{CM} \geq V_S$

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

Low V_{SENSE} Case 1: $V_{SENSE} < 20$ mV, -16 V $\leq V_{CM} < 0$

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

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

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

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).

$$G = \frac{V_{OUT1} - V_{OUT2}}{100\text{ mV} - 20\text{ mV}} \quad (1)$$

Where:

V_{OUT1} = Output voltage with V_{SENSE} = 100 mV

V_{OUT2} = Output voltage with V_{SENSE} = 20 mV

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

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

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

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

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

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

Although the INA193A–INA198A 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 INA193A–INA198A. 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 mV for V_{SENSE} = 0 mV. As V_{SENSE} approaches 20 mV, V_{OUT} returns to the expected output value with accuracy as specified in the Electrical Characteristics. Figure 2 illustrates this effect using the INA195A and INA198A (Gain = 100).

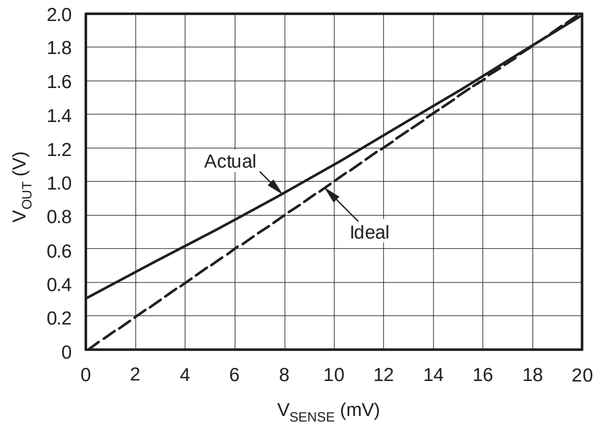
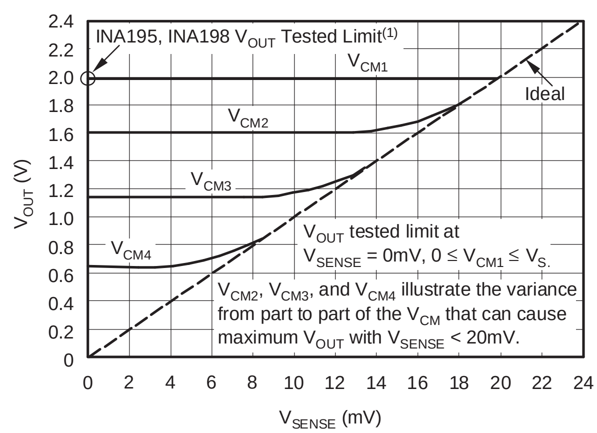


Figure 2. Example for Low V_{SENSE} Cases 1 and 3 (INA195A, INA198A: Gain = 100)

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

This region of operation is the least accurate for the INA193A–INA198A 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 0 V. Within this region, as V_{SENSE} approaches 20 mV, device operation is closer to that described by Normal Case 2. Figure 3 illustrates this behavior for the INA195A. The V_{OUT} maximum peak for this case is tested by maintaining a constant V_S, setting V_{SENSE} = 0 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.



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

Figure 3. Example for Low V_{SENSE} Case 2 (INA195A, INA198A: Gain = 100)

Shutdown

Because the INA193A–INA198A 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 µF bypass capacitor, preferably ceramic with good high frequency characteristics. This gate should have a supply voltage of 3 V or greater because the INA193A–INA198A requires a minimum supply greater than 2.7 V. In addition to eliminating quiescent current, this gate also turns off the 10 µA bias current present at each of the inputs. An example shutdown circuit is shown in Figure 4.

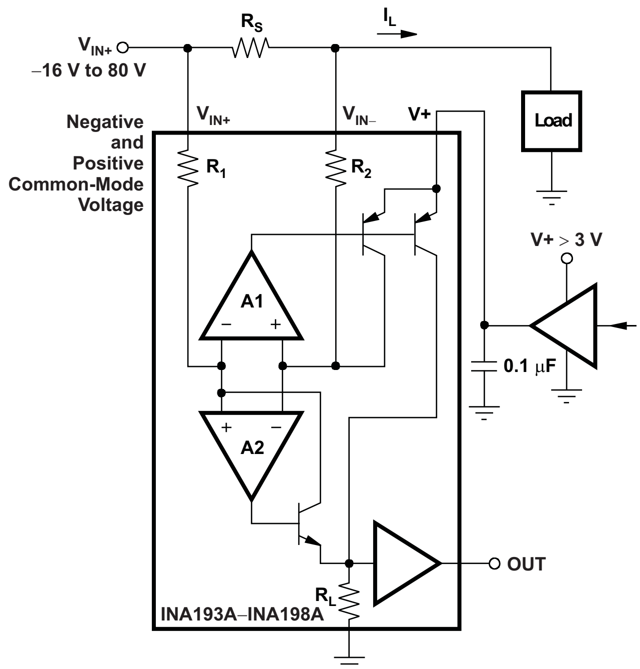


Figure 4. INA193A–INA198A Example Shutdown Circuit

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.

Transient Protection

The –16-V to +80-V common-mode range of the INA19xA 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 INA19xA is exposed to transients on the inputs in excess of its ratings, then external transient absorption with semiconductor transient absorbers (zeners or Transzorbs) are 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 never allows the INA19xA to be exposed to transients greater than 80 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 INA19xA does not lend itself to using external resistors in series with the inputs since the internal gain resistors can vary up to ±30%. (If gain accuracy is not important, then resistors can be added in series with the INA19xA inputs with two equal resistors on each input.)

Output Voltage Range

The output of the INA19xA is accurate within the output voltage swing range set by the power supply pin, V+. This is best illustrated when using the INA195A or INA198A (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 V, and a power-supply voltage sufficient to achieve 10 V on the output.

RFI/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 INA193A–INA195A versus the INA196A–INA198A may provide different EMI performance.

Input Filtering

An obvious and straightforward location for filtering is at the output of the INA19xA 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 INA19xA, which is complicated by the internal 5-kΩ ± 30% input impedance (see Figure 5). 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:

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

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_{FILT} can also be inserted into the equation. If a pair of 100-Ω 1% resistors are used on the inputs, the initial gain error is 1.96%. Worst-case tolerance conditions always occur at the lower excursion of the internal 5-kΩ resistor (3.5 kΩ), and the higher excursion of R_{FILT}, 3% in this case.

Note that the specified accuracy of the INA19xA must then be combined in addition to these tolerances. While this discussion treats 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.

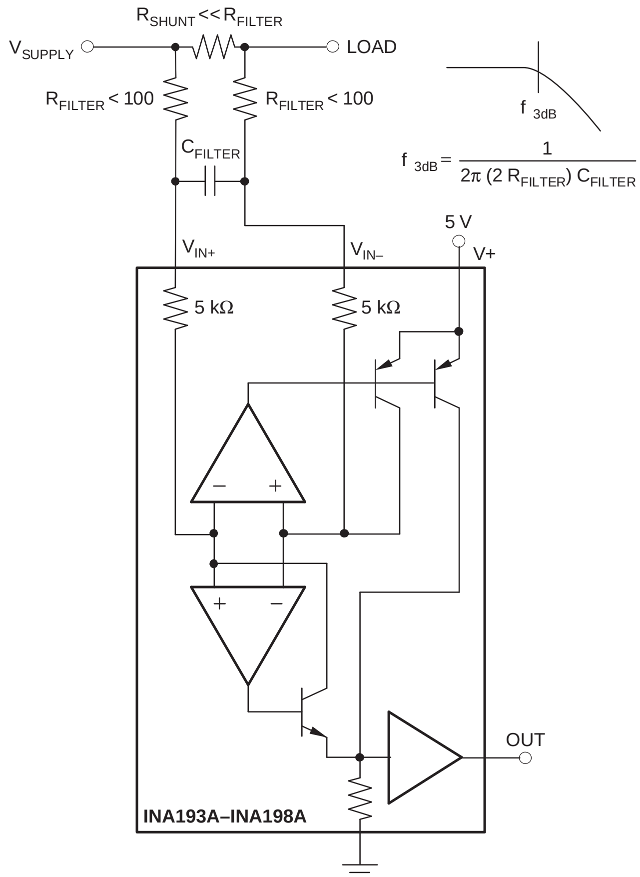


Figure 5. Input Filter (Gain Error = 1.5% to –2.2%)

Inside the INA19xA

The INA19xA uses a new, unique, internal circuit topology that provides common-mode range extending from –16 V 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 INA19xA provides 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 (see Figure 6) shows the basic circuit function. When the common-mode voltage is positive, amplifier A2 is active.

The differential input voltage, $V_{IN+} – V_{IN–}$ applied across R_S, is converted to a current through a 5-kΩ 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 5-kΩ 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.

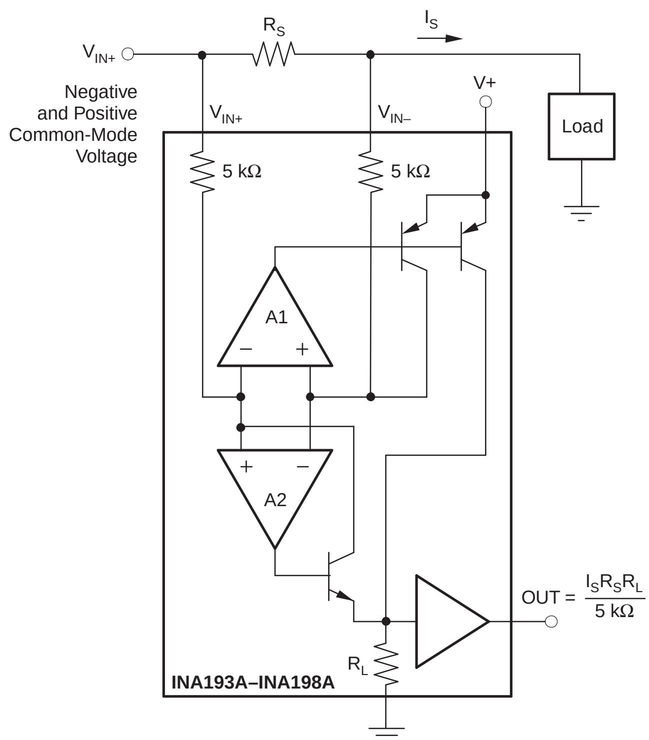


Figure 6. INA19xA Simplified Circuit Diagram

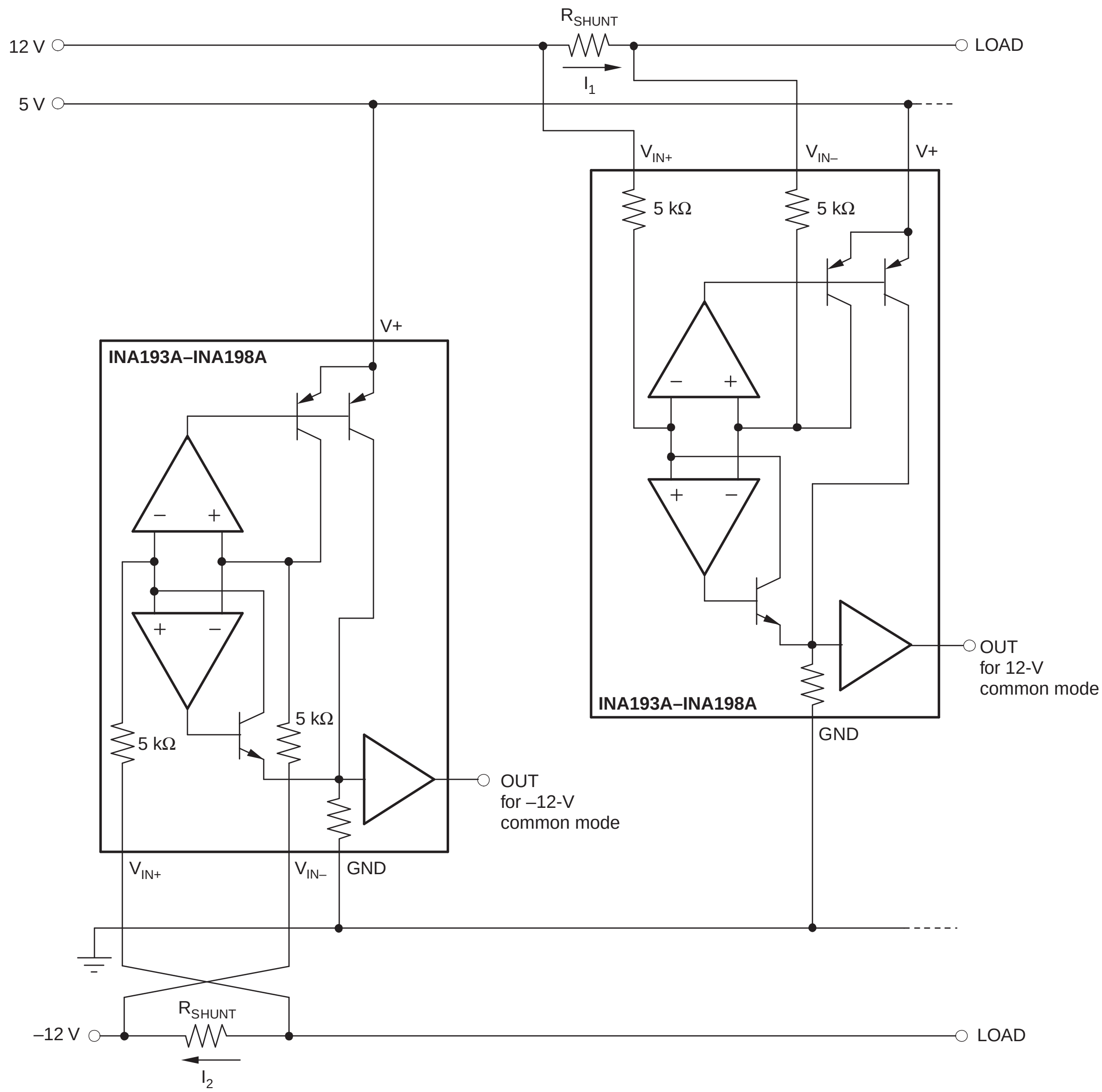


Figure 7. Monitor Bipolar Output Power-Supply Current

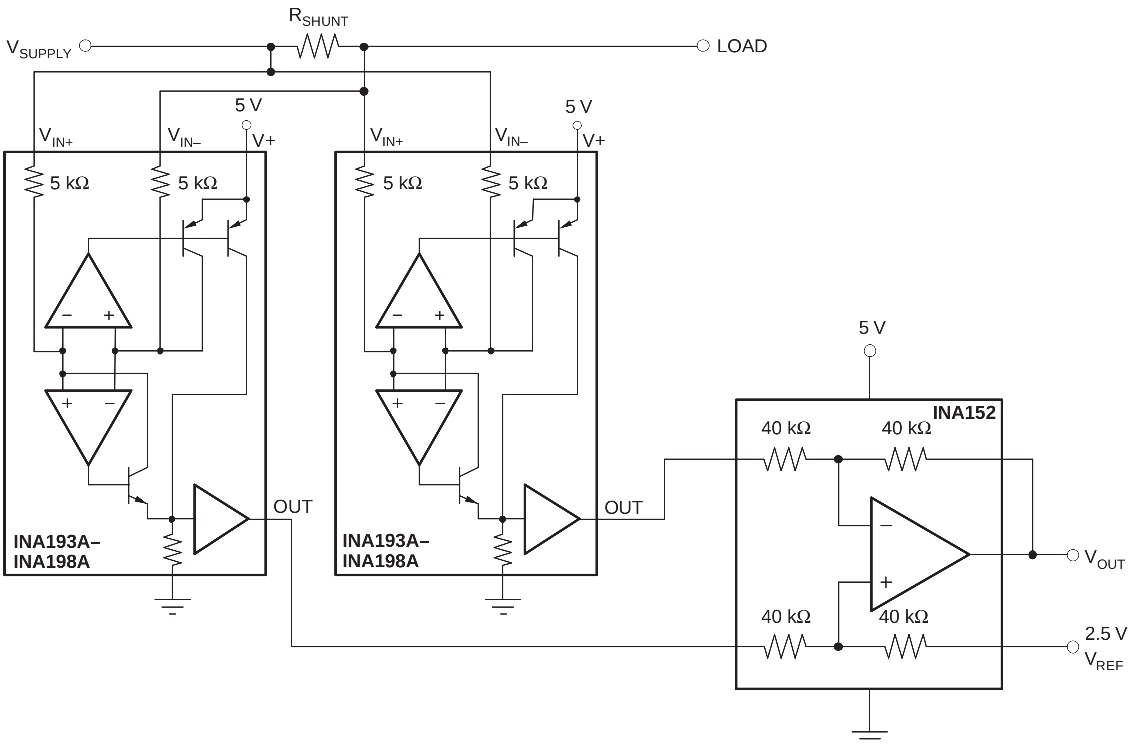


Figure 8. Bidirectional Current Monitoring

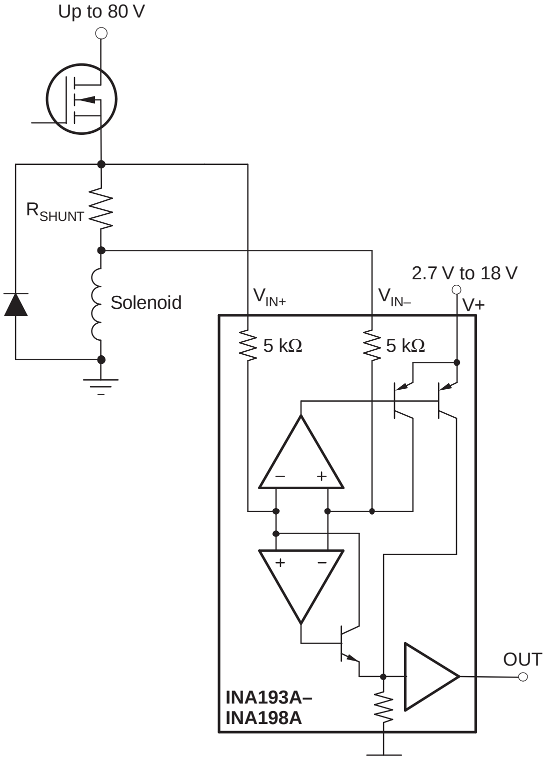
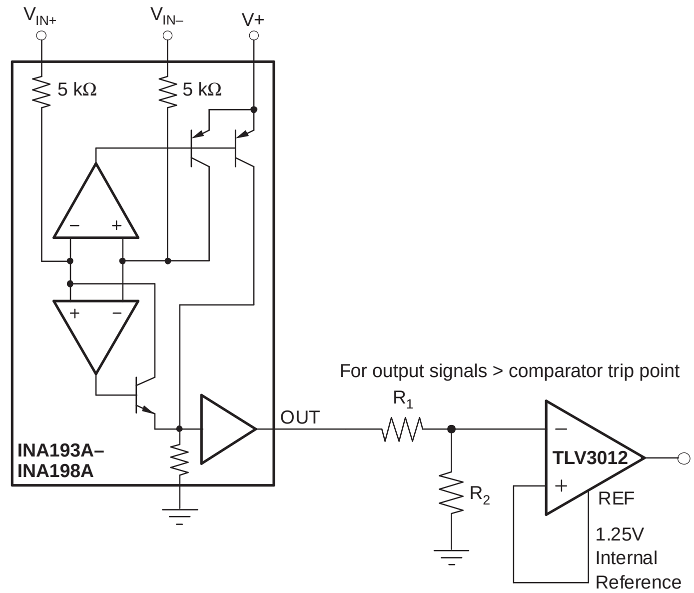
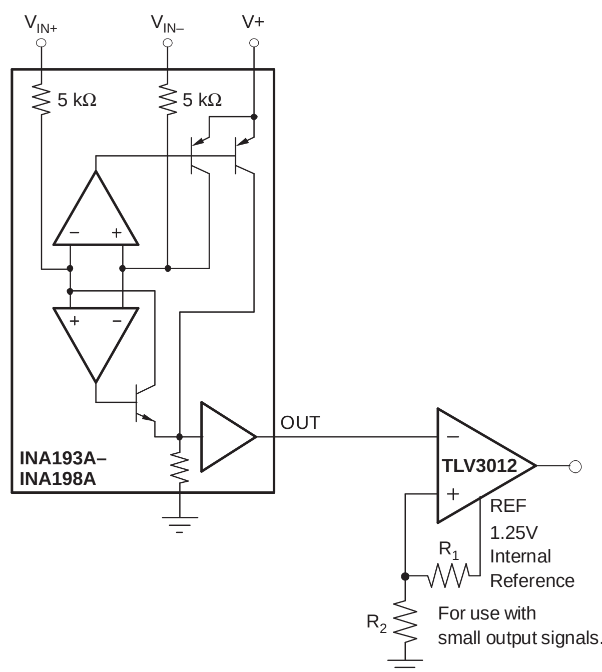


Figure 9. Inductive Current Monitor Including Flyback



(a) INA19xA Output Adjusted by Voltage Divider



(b) Comparator Reference Voltage Adjusted by Voltage Divider

Figure 10. INA19xA With Comparator

PACKAGING INFORMATION

Orderable Device	Status [(1)]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [(2)]	Lead/Ball Finish	MSL Peak Temp [(3)]
INA193AQDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA194AQDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA195AQDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA196AQDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA197AQDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA198AQDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	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.
OBSOLETE: 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.

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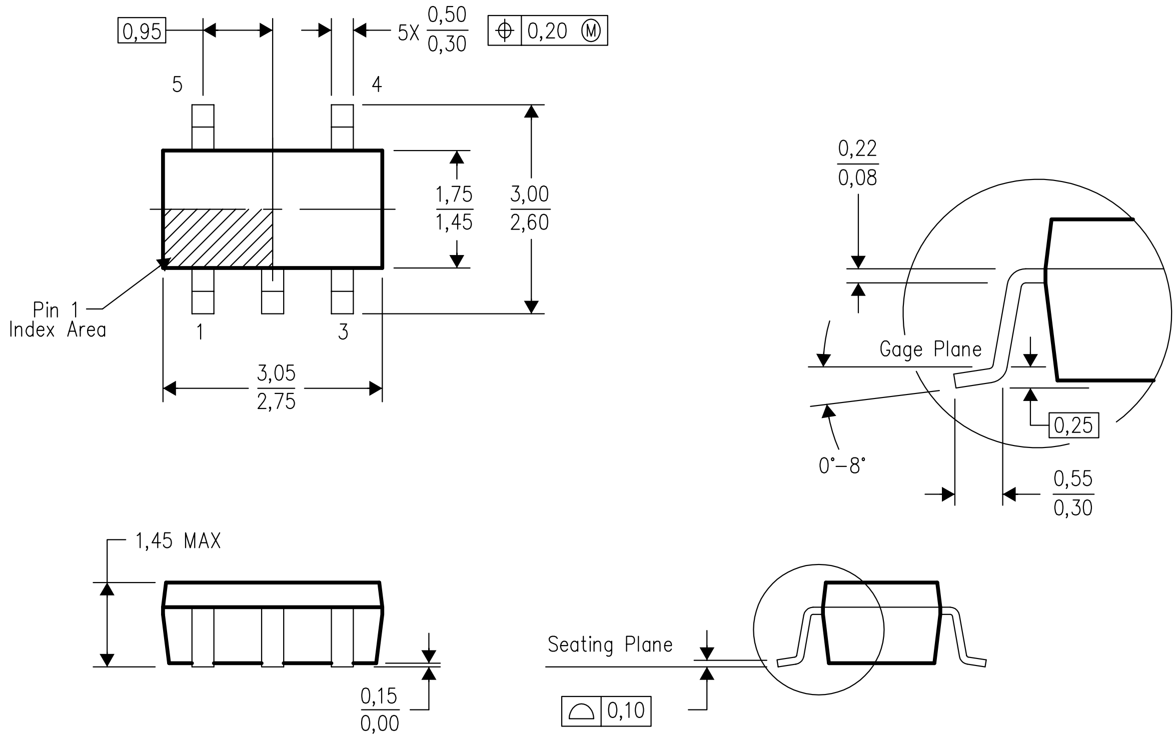
DBV (R-PDSO-G5) PLASTIC SMALL-OUTLINE PACKAGE



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
D. Falls within JEDEC MO-178 Variation AA.

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