Burr-Brown Products
from Texas Instruments

INA193, INA194
INA195, INA196
INA197, INA198

SBOS307E − MAY 2004 − REVISED AUGUST 2006

CURRENT SHUNT MONITOR

−16V to +80V Common-Mode Range

FEATURES

- **WIDE COMMON-MODE VOLTAGE: −16V to +80V**
- **LOW ERROR: 3.0% Over Temp (max)**
- **BANDWIDTH: Up to 500kHz**
- **THREE TRANSFER FUNCTIONS AVAILABLE: 20V/V, 50V/V, and 100V/V**
- **QUIESCENT CURRENT: 900μA (max)**
- **COMPLETE CURRENT SENSE SOLUTION**

APPLICATIONS

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

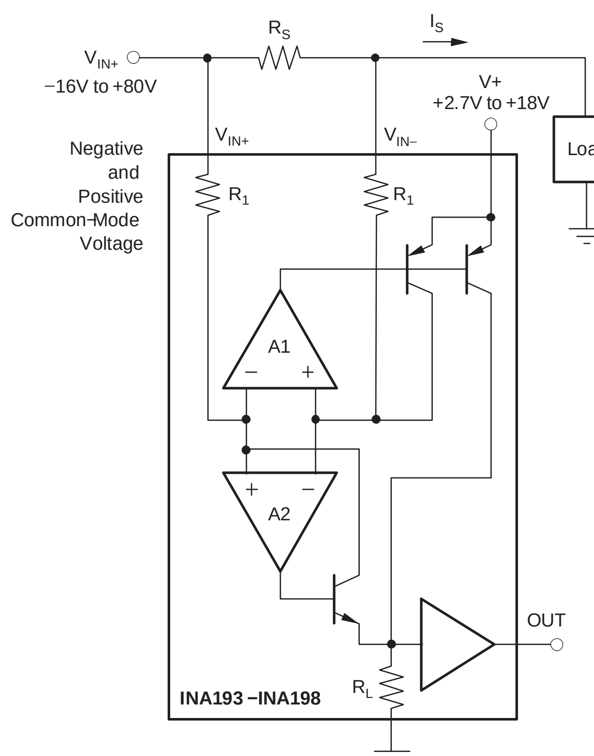
MODEL	GAIN	PACKAGE	PINOUT(1)
INA193	20V/V	SOT23-5	Pinout #1
INA194	50V/V	SOT23-5	Pinout #1
INA195	100V/V	SOT23-5	Pinout #1
INA196	20V/V	SOT23-5	Pinout #2
INA197	50V/V	SOT23-5	Pinout #2
INA198	100V/V	SOT23-5	Pinout #2

(1) See Pin Assignments for Pinout #1 and Pinout #2.

DESCRIPTION

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

The INA193−INA198 operate from a single +2.7V to +18V supply, drawing a maximum of 900μA of supply current. They are specified over the extended operating temperature range (−40°C to +125°C), and are offered in a space-saving SOT23 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.

ABSOLUTE MAXIMUM RATINGS(1)

Supply Voltage	+18V
Analog Inputs, V_{IN+}, V_{IN-}	
Differential (V_{IN+}) − (V_{IN-})	−18V to +18V
Common-Mode(2)	−16V to +80V
Analog Output, Out(2)	GND − 0.3V to (V+) + 0.3V
Input Current Into Any Pin(2)	5mA
Operating Temperature	−55°C to +150°C
Storage Temperature	−65°C to +150°C
Junction Temperature	+150°C
ESD Ratings	
Human Body Model	4000V
Charged-Device Model	1000V

(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) Input voltage at any pin may exceed the voltage shown if the current at that pin is limited to 5mA.

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.

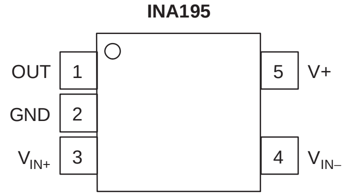
PACKAGE INFORMATION(1)

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR	PACKAGE MARKING
INA193	SOT23-5	DBV	BJJ
INA194	SOT23-5	DBV	BJI
INA195	SOT23-5	DBV	BJK
INA196	SOT23-5	DBV	BJE
INA197	SOT23-5	DBV	BJH
INA198	SOT23-5	DBV	BJL

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

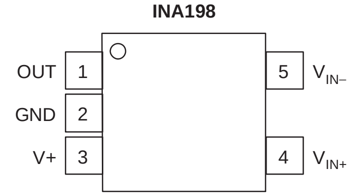
PIN ASSIGNMENTS

INA193
INA194
INA195



SOT23−5
(Pinout #1)

INA196
INA197
INA198

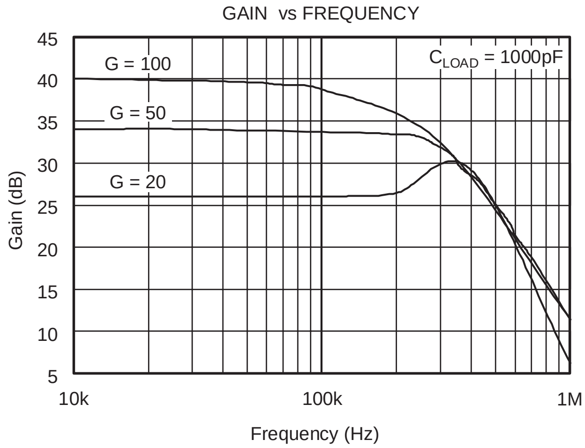


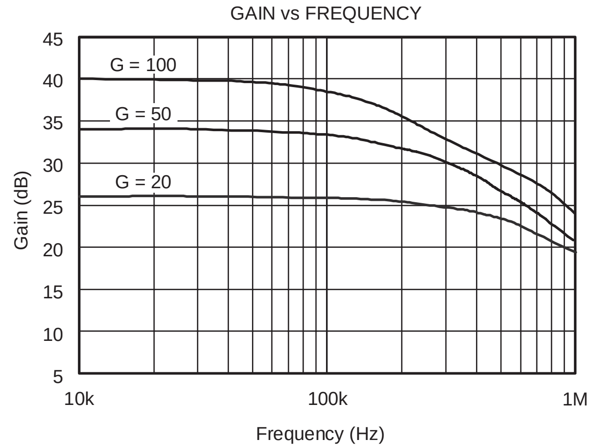
SOT23−5
(Pinout #2)

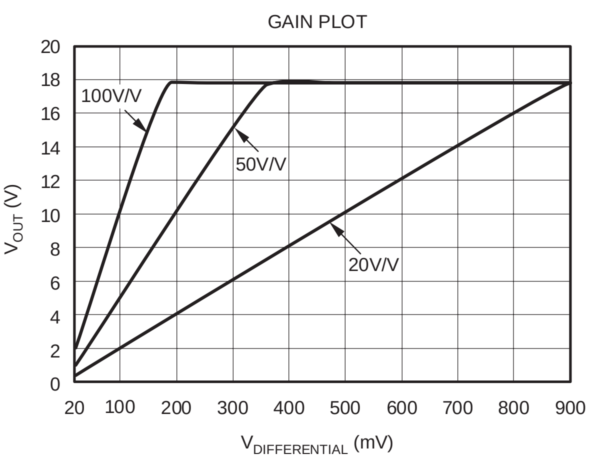
TEXAS INSTRUMENTS
www.ti.com

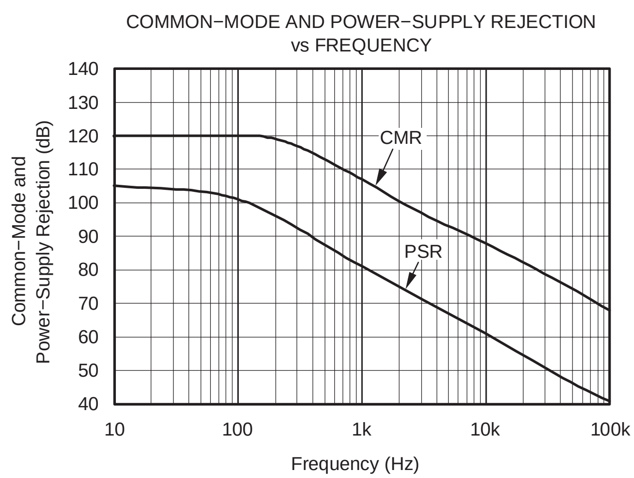
TYPICAL CHARACTERISTICS

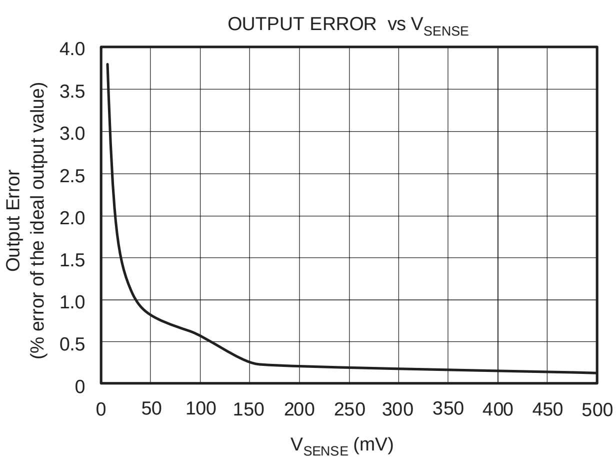
All specifications at T_A = +25°C, V_S = +12V, and V_{IN+} = 12V, and V_{SENSE} = 100mV, unless otherwise noted.

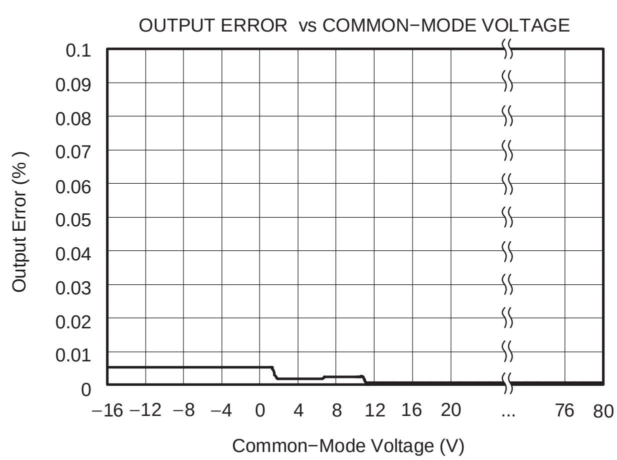






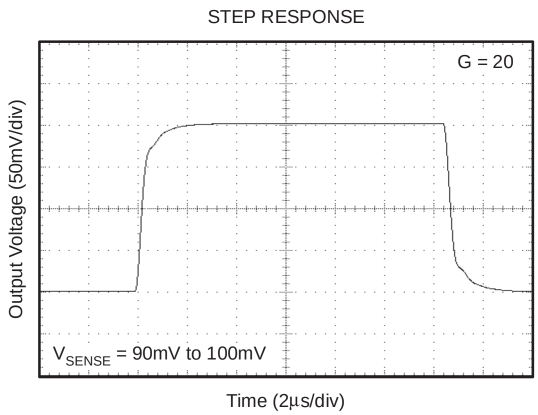


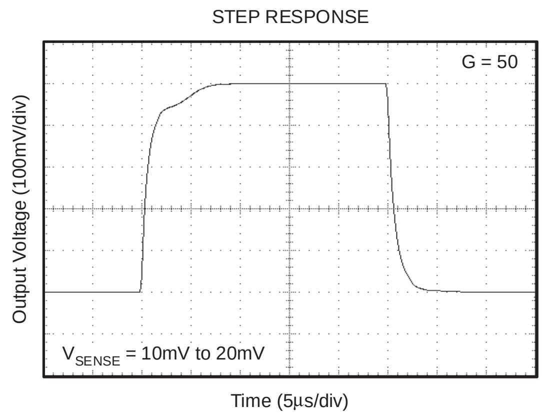


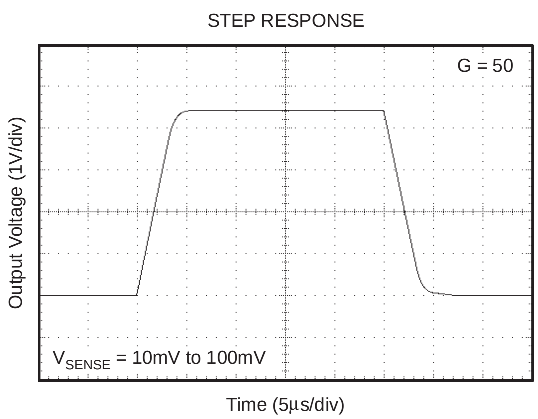


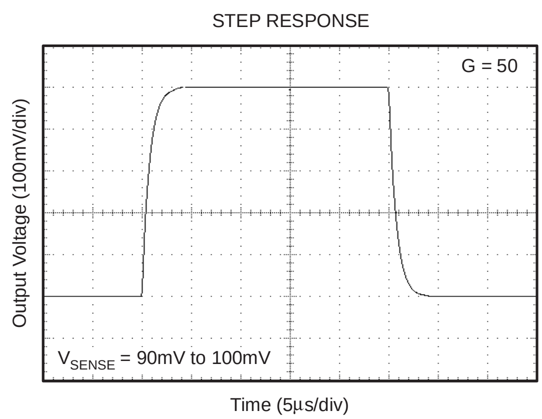
TYPICAL CHARACTERISTICS (continued)

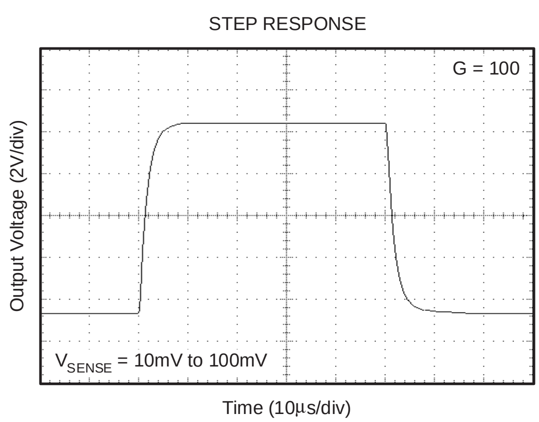
All specifications at T_A = +25°C, V_S = +12V, and V_{IN+} = 12V, and V_{SENSE} = 100mV, unless otherwise noted.











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. 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 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. 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 2 illustrates this effect using the INA195 and INA198 (Gain = 100).

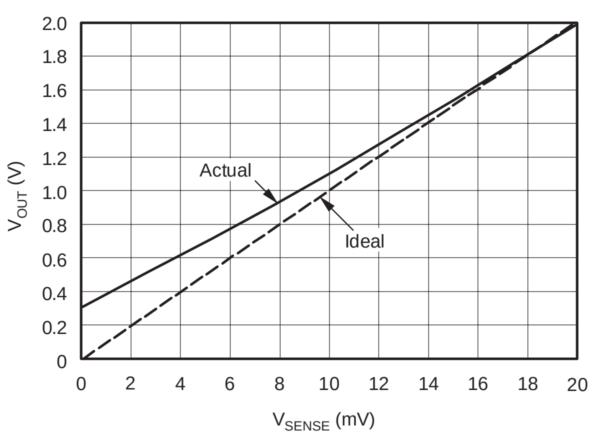
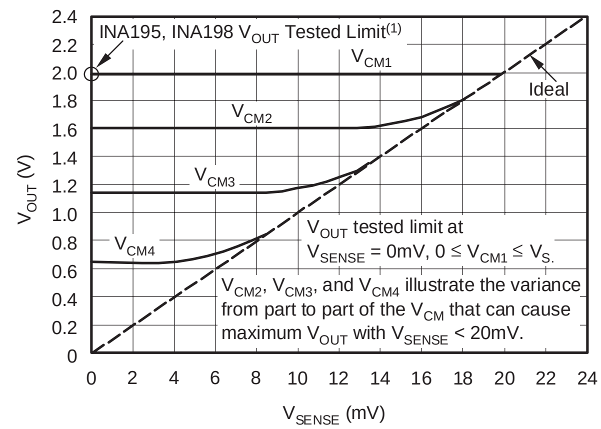


Figure 2. Example for Low V_{SENSE} Cases 1 and 3 (INA195, INA198: Gain = 100)

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 INA193−INA198 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 3 illustrates this behavior for the INA195. 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.



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 (INA195, INA198: Gain = 100)

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 INA193-INA195 vs. the INA196-INA198 may provide different EMI performance.

INPUT FILTERING

An obvious and straightforward location for filtering is at the output of the INA193-INA198; 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, which is complicated by the internal 5kΩ + 30% input impedance; this is illustrated in 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:

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

Total effect on gain error can be calculated by replacing the 5kΩ term with 5kΩ − 30%, (or 3.5kΩ) or 5kΩ + 30% (or 6.5kΩ). 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 approximately 2%. Worst-case tolerance conditions will always occur at the lower excursion of the internal 5kΩ resistor (3.5kΩ), and the higher excursion of R_{FILT} − 3% in this case.

Note that the specified accuracy of the INA193-INA198 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.

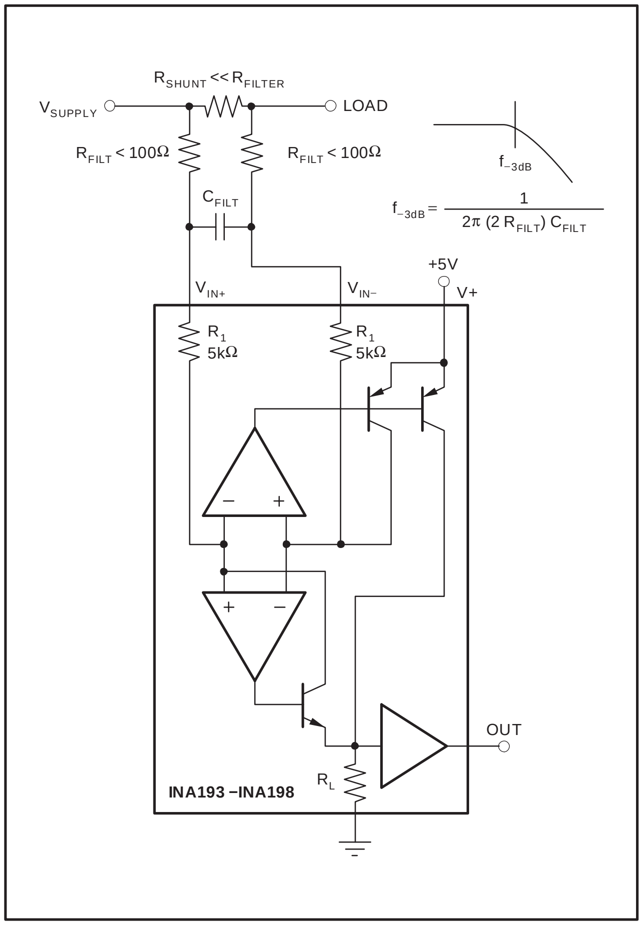


Figure 5. Input Filter (Gain Error − 1.5% to −2.2%)

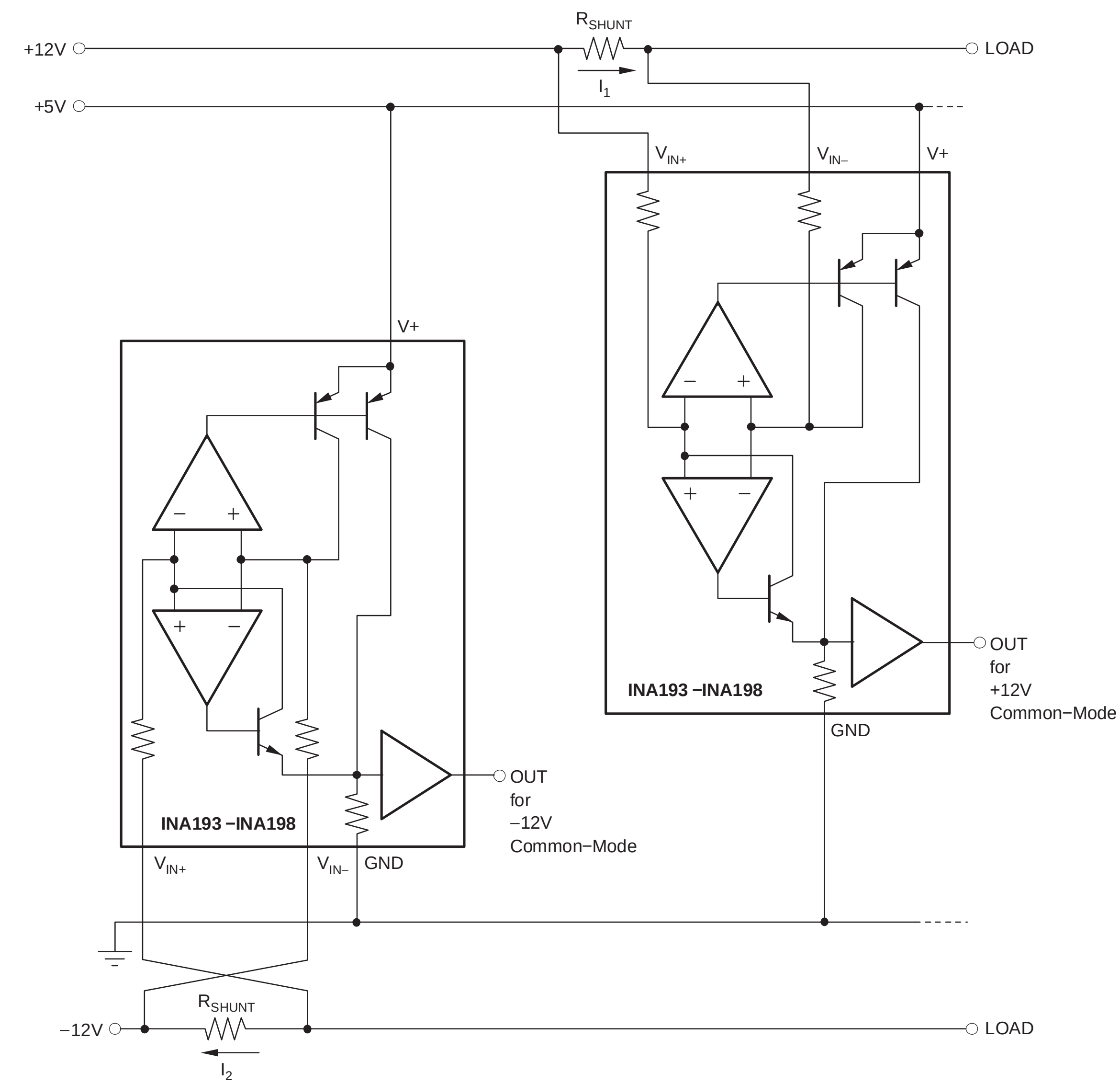
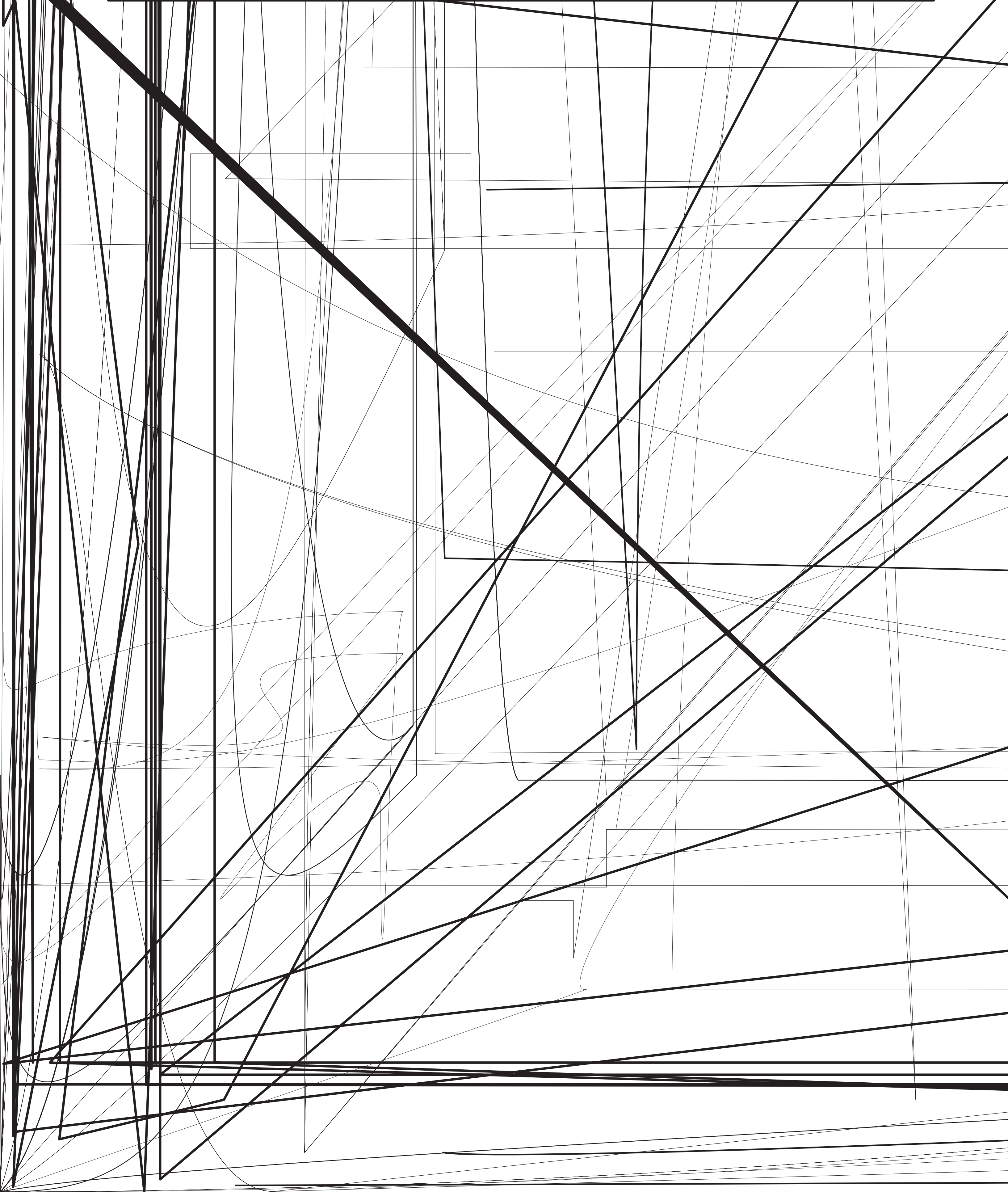
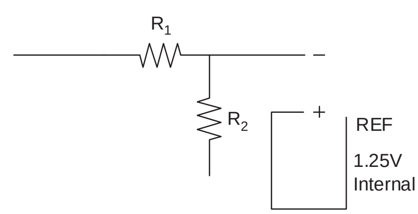


Figure 7. Monitor Bipolar Output Power-Supply Current




R1
R2
−
+
REF
1.25V
Internal

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
INA193AIDBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA193AIDBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA193AIDBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA193AIDBVTG4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA194AIDBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA194AIDBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA194AIDBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA194AIDBVTG4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA195AIDBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA195AIDBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA195AIDBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA195AIDBVTG4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA196AIDBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA196AIDBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA196AIDBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA196AIDBVTG4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA197AIDBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA197AIDBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA197AIDBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA197AIDBVTG4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA198AIDBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA198AIDBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA198AIDBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
INA198AIDBVTG4	ACTIVE	SOT-23	DBV	5	250	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.

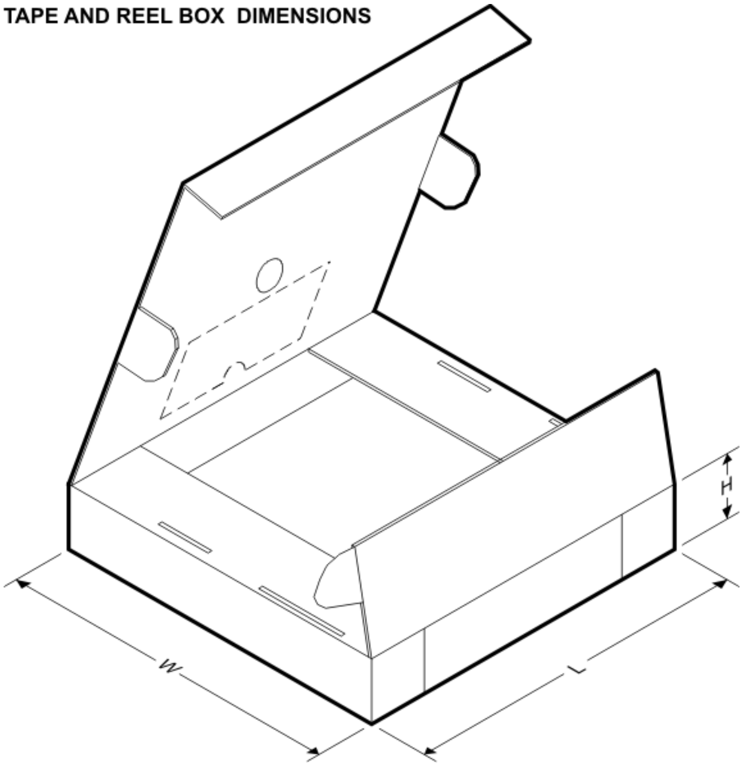
(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been 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.

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.

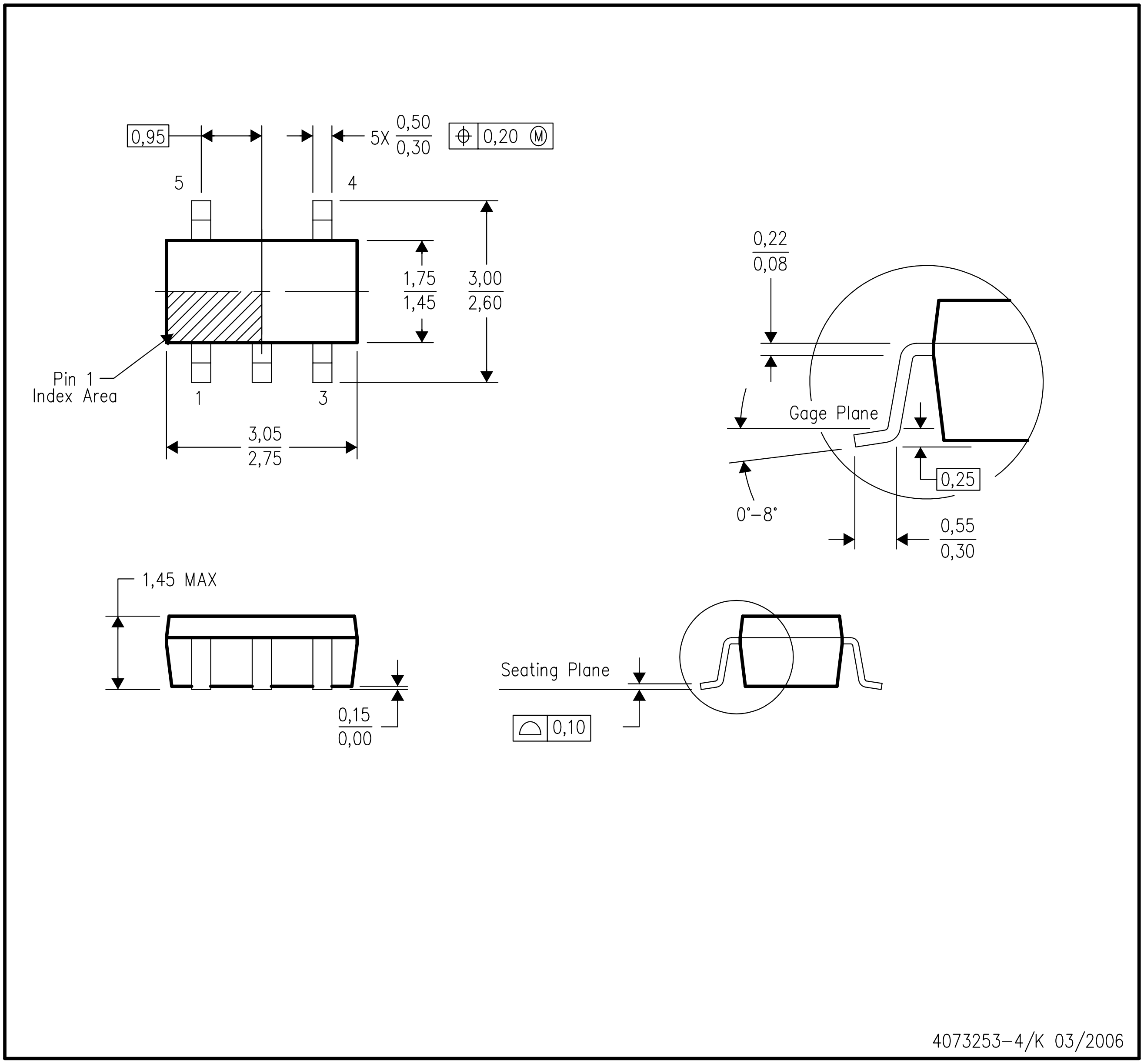
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
INA193AIDBVR	SOT-23	DBV	5	3000	190.5	212.7	31.8
INA193AIDBVT	SOT-23	DBV	5	250	190.5	212.7	31.8
INA194AIDBVR	SOT-23	DBV	5	3000	190.5	212.7	31.8
INA194AIDBVT	SOT-23	DBV	5	250	190.5	212.7	31.8
INA195AIDBVR	SOT-23	DBV	5	3000	190.5	212.7	31.8
INA195AIDBVT	SOT-23	DBV	5	250	190.5	212.7	31.8
INA196AIDBVR	SOT-23	DBV	5	3000	190.5	212.7	31.8
INA196AIDBVT	SOT-23	DBV	5	250	190.5	212.7	31.8
INA197AIDBVR	SOT-23	DBV	5	3000	190.5	212.7	31.8
INA197AIDBVT	SOT-23	DBV	5	250	190.5	212.7	31.8
INA198AIDBVR	SOT-23	DBV	5	3000	190.5	212.7	31.8
INA198AIDBVT	SOT-23	DBV	5	250	190.5	212.7	31.8

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.