



**Burr-Brown Products**  
from Texas Instruments

**INA166**



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## Low-Noise, Low-Distortion, $G = 2000$ INSTRUMENTATION AMPLIFIER

### FEATURES

- LOW NOISE:  $1.3\text{nV}/\sqrt{\text{Hz}}$  at 1kHz
- LOW THD+N: 0.09% at 1kHz
- WIDE BANDWIDTH: 450kHz
- WIDE SUPPLY RANGE:  $\pm 4.5\text{V}$  to  $\pm 18\text{V}$
- HIGH CMR:  $> 100\text{dB}$
- GAIN SET WITH EXTERNAL RESISTOR
- SO-14 SURFACE-MOUNT PACKAGE

### APPLICATIONS

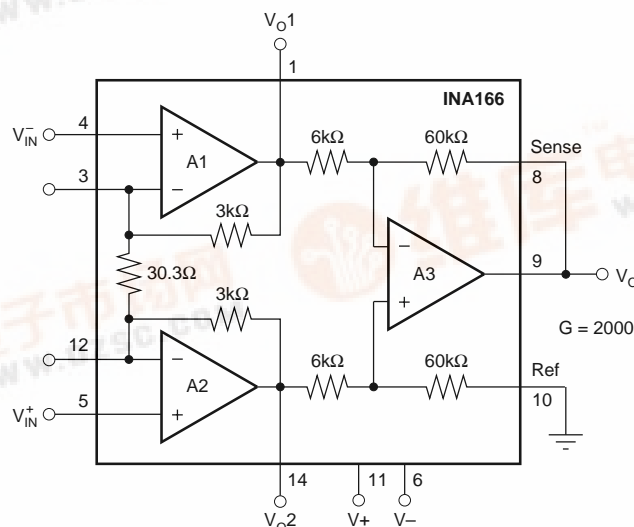
- MOVING-COIL TRANSDUCER AMPLIFIERS
- DIFFERENTIAL RECEIVERS
- BRIDGE TRANSDUCER AMPLIFIERS
- MICROPHONE AND HYDROPHONE PREAMPS

### DESCRIPTION

The INA166 is a very low-noise, low-distortion, monolithic instrumentation amplifier. Its current-feedback circuitry achieves very wide bandwidth and excellent dynamic response over a wide range of gain. It is ideal for low-level signals such as microphones or hydrophones. Many industrial, instrumentation, and medical applications also benefit from its low noise and wide bandwidth.

Unique distortion cancellation circuitry reduces distortion to extremely low levels, even in high gain. The INA166 provides near-theoretical noise performance for  $200\Omega$  source impedance. Its differential input, low noise, and low distortion provide superior performance as a low-level signal amplifier.

The INA166 is available in a space-saving SO-14 surface-mount package, specified for operation over the  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  temperature range.

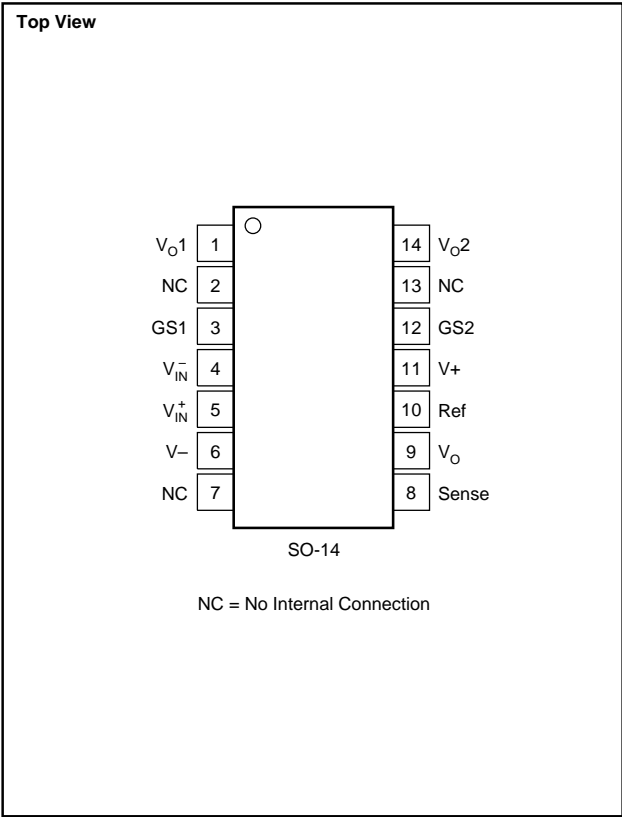


# SPECIFICATIONS: $V_S = \pm 5V$

$T_A = +25^{\circ}C$  and at rated supplies,  $V_S = \pm 5V$ ,  $R_L = 2k\Omega$  connected to ground,  $G = 2000$ , unless otherwise noted.

PARAMETER	CONDITIONS	INA166UA			UNITS
		MIN	TYP	MAX	
<b>GAIN</b> Gain Error Gain Temp Drift Coefficient Nonlinearity			$\pm 0.3$ $\pm 10$ $\pm 0.005$	$\pm 1$	% ppm/ $^{\circ}C$ % of FS
<b>INPUT REFERRED NOISE</b> Voltage Noise $f_O = 1kHz$ $f_O = 100Hz$ $f_O = 10Hz$ Current Noise $f_O = 1kHz$	$R_{SOURCE} = 0\Omega$		1.3 1.6 2  0.8		nV/ $\sqrt{Hz}$ nV/ $\sqrt{Hz}$ nV/ $\sqrt{Hz}$  pA/ $\sqrt{Hz}$
<b>INPUT OFFSET VOLTAGE</b> Input Offset Voltage vs Temperature vs Power Supply	$V_{CM} = V_{OUT} = 0V$ $T_A = T_{MIN}$ to $T_{MAX}$ $V_S = \pm 4.5V$ to $\pm 18V$		$\pm 50$ $\pm 2.5$ $\pm 1$	$\pm 250$  $\pm 3$	$\mu V$ $\mu V/^{\circ}C$ $\mu V/V$
<b>INPUT VOLTAGE RANGE</b> Common-Mode Voltage Range  Common-Mode Rejection	$V_{IN}^{+} - V_{IN}^{-} = 0V$ $V_{IN}^{+} - V_{IN}^{-} = 0V$ $V_{CM} = \pm 1V$ , $R_{SRC} = 0\Omega$	(V+) - 4 (V-) + 4 100	(V+) - 3 (V-) + 3 120		V V dB
<b>INPUT BIAS CURRENT</b> Initial Bias Current vs Temperature Initial Offset Current vs Temperature			2.5 15 0.1 0.5	12  1	$\mu A$ nA/ $^{\circ}C$ $\mu A$ nA/ $^{\circ}C$
<b>INPUT IMPEDANCE</b>	Differential Common-Mode		60    2 60    2		M $\Omega$    pF M $\Omega$    pF
<b>DYNAMIC RESPONSE</b> Bandwidth, Small Signal, -3dB Slew Rate THD+Noise, $f = 1kHz$ Settling Time, 0.1% 0.01% Overload Recovery	5V Step 5V Step 50% Overdrive		450 15 0.09 2.5 3.5 1		kHz V/ $\mu s$ % $\mu s$ $\mu s$ $\mu s$
<b>OUTPUT</b> Voltage  Load Capacitance Stability Short-Circuit Current	$R_L = 2k\Omega$ to Ground  Continuous-to-Common	(V+) - 2 (V-) + 2	(V+) - 1.8 (V-) + 1.8 1000 $\pm 60$		V V pF mA
<b>POWER SUPPLY</b> Rated Voltage Voltage Range Current, Quiescent	$I_O = 0mA$	$\pm 4.5$	$\pm 5$ $\pm 10$	$\pm 18$ $\pm 12$	V V mA
<b>TEMPERATURE RANGE</b> Specification Operating Thermal Resistance, $\theta_{JA}$		-40 -40	100	+85 +125	$^{\circ}C$ $^{\circ}C$ $^{\circ}C/W$

PIN CONFIGURATION



ELECTROSTATIC  
DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Burr-Brown 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.

ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

Power Supply Voltage .....	±18V
Signal Input Terminals, Voltage <sup>(2)</sup> .....	(V-) - 0.5V to (V+) + 0.5V
Current <sup>(2)</sup> .....	10mA
Output Short-Circuit to Ground .....	Continuous
Operating Temperature .....	-55°C to +125°C
Storage Temperature .....	-55°C to +125°C
Junction Temperature .....	+150°C
Lead Temperature (soldering, 10s) .....	+300°C

NOTES: (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 implied. (2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current limited to 10mA or less.

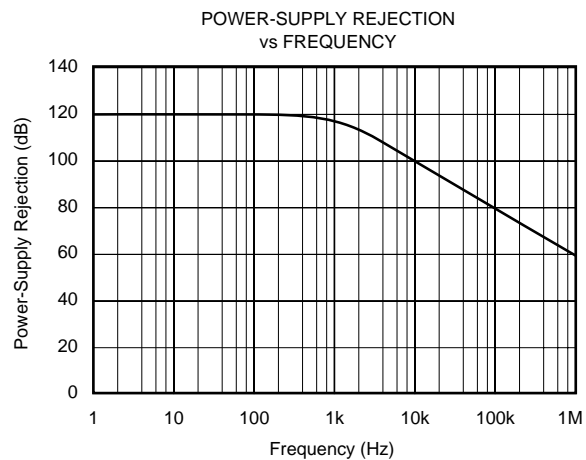
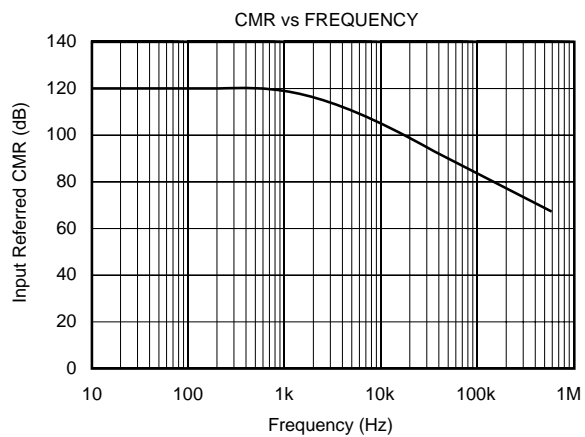
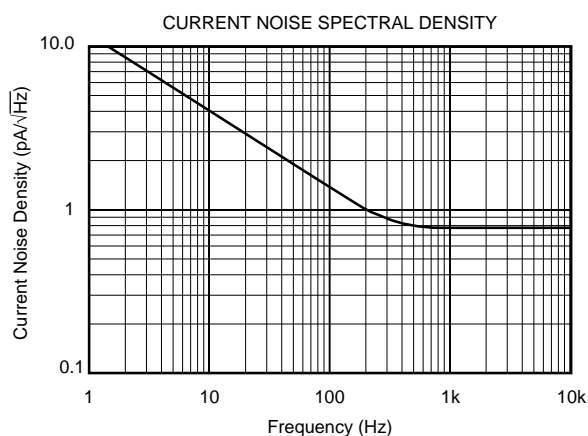
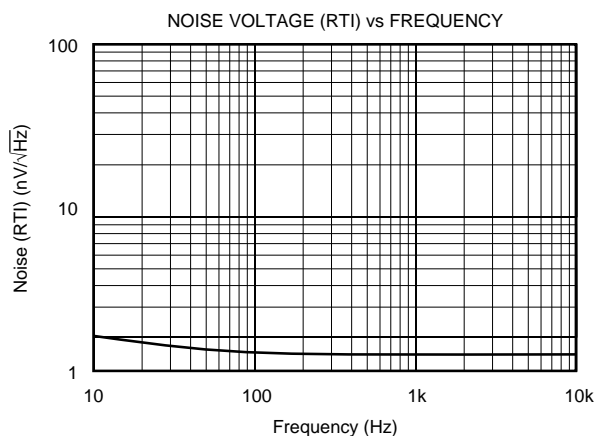
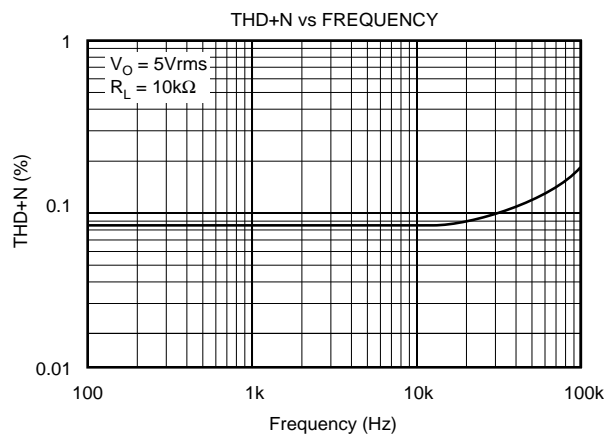
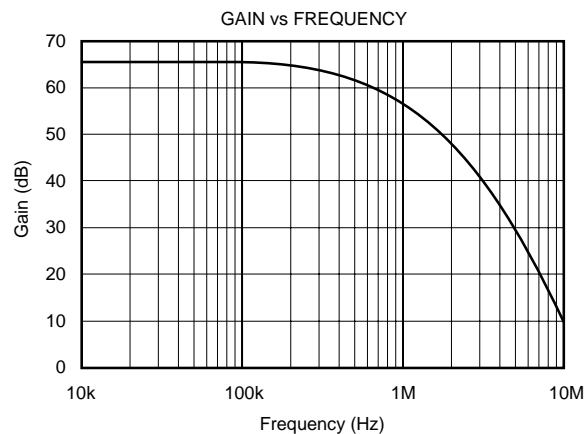
PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER	PACKAGE MARKING	ORDERING NUMBER <sup>(1)</sup>	TRANSPORT MEDIA
INA166UA "	SO-14 Surface Mount "	235 "	INA166UA "	INA166UA INA166UA/2K5	Rails Tape and Reel

NOTE: (1) Models with a slash (/) are available only in Tape and Reel in the quantities indicated (e.g., /2K5 indicates 2500 devices per reel). Ordering 2500 pieces of "INA166UA/2K5" will get a single 2500-piece Tape and Reel.

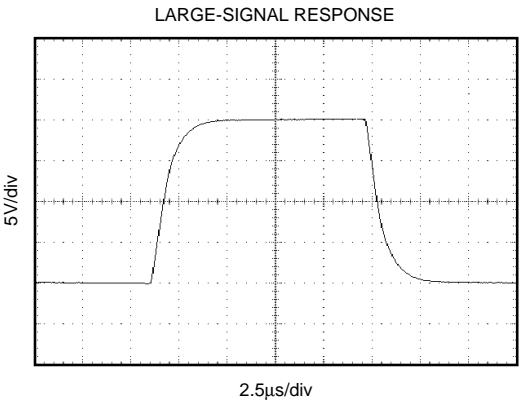
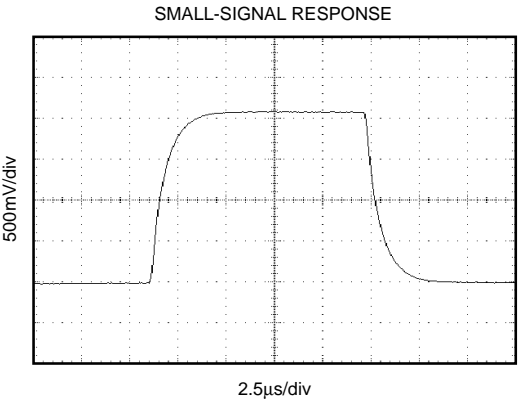
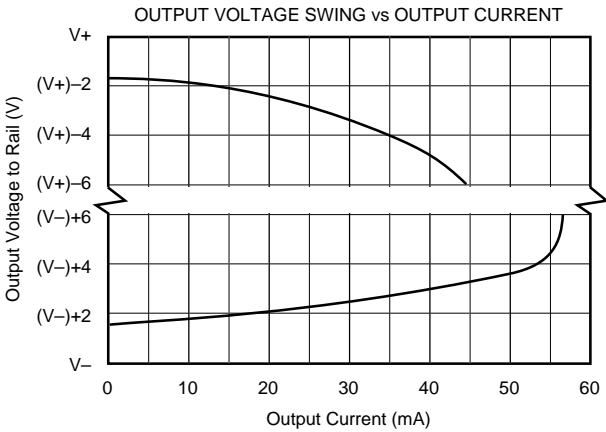
# TYPICAL PERFORMANCE CURVES

At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 5\text{V}$ ,  $R_L = 2\text{k}\Omega$ ,  $C_L = 50\text{pF}$ ,  $G = 2000$ , unless otherwise noted.



# TYPICAL PERFORMANCE CURVES (Cont.)

At  $T_A = +25^{\circ}\text{C}$ ,  $V_S = \pm 5\text{V}$ ,  $R_L = 2\text{k}\Omega$ ,  $C_L = 50\text{pF}$ ,  $G = 2000$ , unless otherwise noted.



# APPLICATIONS INFORMATION

Figure 1 shows the basic connections required for operation. Power supplies should be bypassed with 0.1µF tantalum capacitors near the device pins. The output Sense (pin 8) and output Reference (pin 10) should be low-impedance connections. Resistance of greater than 5Ω in series with these connections will degrade the common-mode rejection of the INA166.

## GAIN

Gain of the INA166 is internally set for  $G = 2000$ . Input stage (A1, A2) gain is 200 and the output stage gain (A3) is 10. Internal resistor values are laser trimmed for accurate ratios to achieve excellent gain accuracy and common-mode rejection, but absolute resistor values are approximately  $\pm 20\%$ . Nominal resistor values are shown.

Although the INA166 is primarily intended for fixed-gain applications, the gain can be increased by connecting a gain-set resistor,  $R_G$ , between pin 3 and pin 12. The nominal gain will be:

$$G = 2000 + \frac{60000}{R_G}$$

Accuracy of the 60000 term in this equation is approximately  $\pm 20\%$ . The stability and temperature drift of  $R_G$  contributes to the overall gain accuracy and these effects can be inferred from this gain equation.

## NOISE PERFORMANCE

The INA166 provides very low-noise with low-source impedance. Its  $1.3\text{nV}/\sqrt{\text{Hz}}$  voltage noise delivers near-theoretical noise performance with a source impedance of  $200\Omega$ .

The input stage design used to achieve this low noise, results in relatively high input bias current and input bias current noise. As a result, the INA166 may not provide the best noise performance with a source impedance greater than  $10\text{k}\Omega$ . For source impedance greater than  $10\text{k}\Omega$ , other instrumentation amplifiers may provide improved noise performance.

## INPUT CONSIDERATIONS

Very low source impedance (less than  $10\Omega$ ) can cause the INA166 to oscillate. This depends on circuit layout, signal source, and input cable characteristics. An input network consisting of a small inductor and resistor, as shown in Figure 2, can greatly reduce any tendency to oscillate. This is especially useful if a variety of input sources are to be connected to the INA166. Although not shown in other figures, this network can be used as needed with all applications shown.

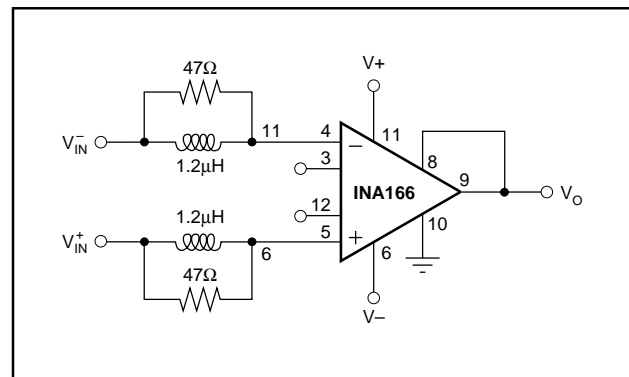


FIGURE 2. Input Stabilization Network.

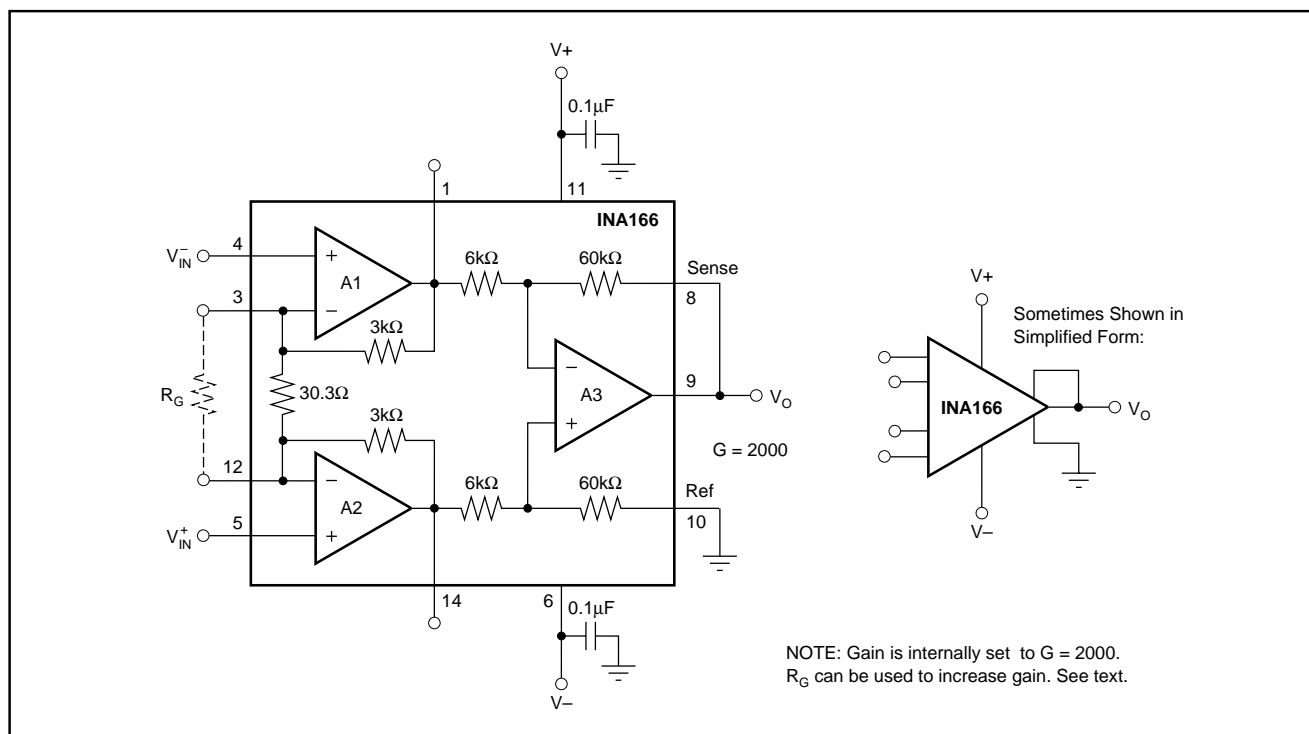


FIGURE 1. Basic Circuit Connections.

**OFFSET VOLTAGE TRIM**

A variable voltage applied to pin 10, as shown in Figure 3, can be used to adjust the output offset voltage. A voltage applied to pin 10 is summed with the output signal. An op amp connected as a buffer is used to provide a low impedance at pin 10 to assure good common-mode rejection.

**OUTPUT SENSE**

An output sense terminal allows greater gain accuracy in driving the load. By connecting the sense connection at the load,  $I \cdot R$  voltage loss to the load is included inside the feedback loop. Current drive can be increased by connecting a buffer amp inside the feedback loop, as shown in Figure 4.

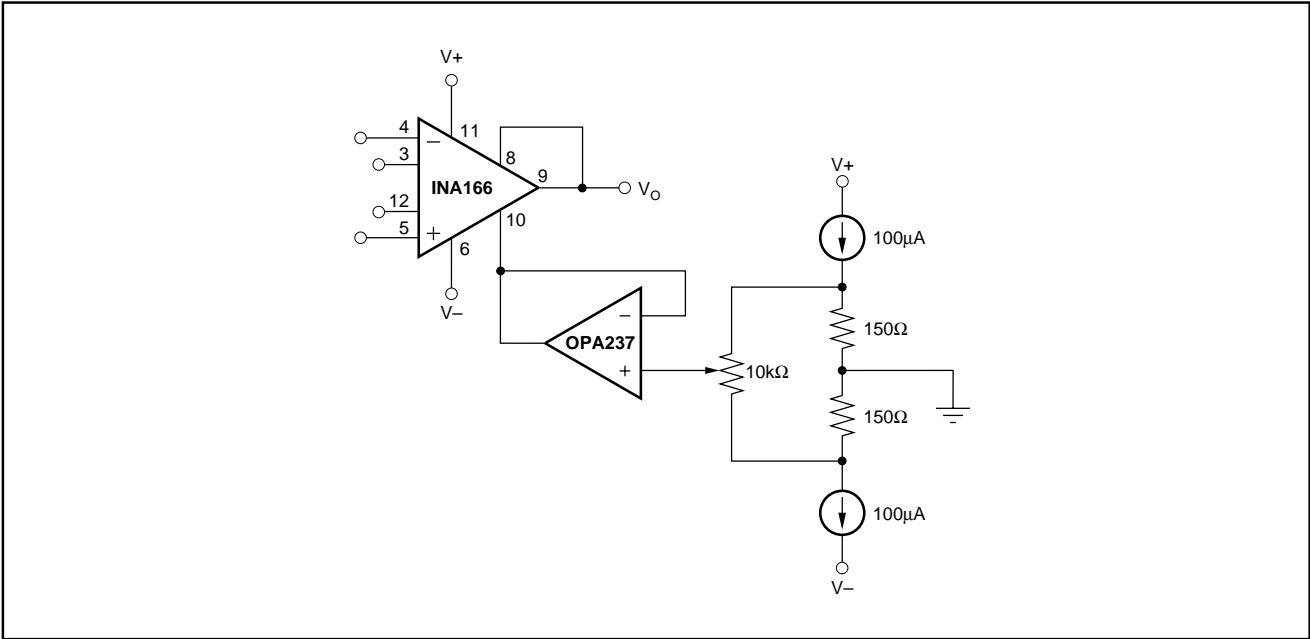


FIGURE 3. Offset Voltage Adjustment Circuit.

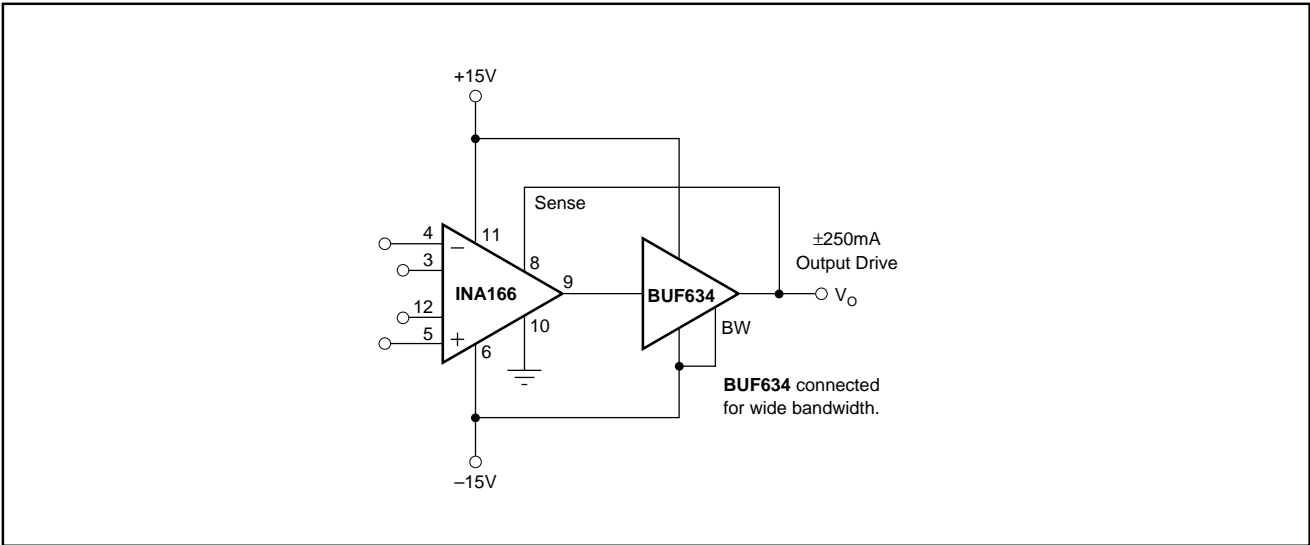


FIGURE 4. Buffer for Increase Output Current.

## PACKAGING INFORMATION

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
INA166UA	ACTIVE	SOIC	D	14	58	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA166UA/2K5	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA166UA/2K5G4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR

<sup>(1)</sup> 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.

<sup>(2)</sup> 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)

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

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