Burr-Brown Products from Texas Instruments

INA166

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

FEATURES

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

APPLICATIONS

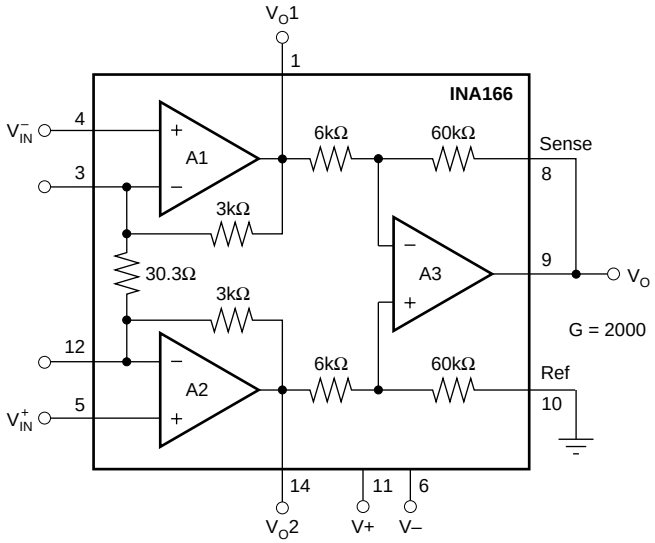
- MOVING-COIL TRANSDUCER AMPLIFIERS
- DIFFERENTIAL RECEIVERS
- BRIDGE TRANSDUCER AMPLIFIERS
- MICROPHONE AND HYDROPHONE PREAMPS

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 200Ω 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°C to +85°C temperature range.



TEXAS INSTRUMENTS

Printed in U.S.A. December, 2000

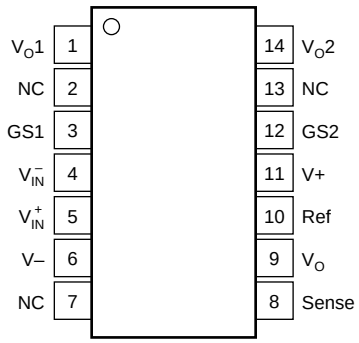
SPECIFICATIONS: $V_S = \pm 5V$

T_A = +25°C and at rated supplies, V_S = ±5V, R_L = 2kΩ connected to ground, G = 2000, unless otherwise noted.

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

PIN CONFIGURATION

Top View



SO-14

NC = No Internal Connection

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[1]

Power Supply Voltage	±18V
Signal Input Terminals, Voltage[2]	(V–) – 0.5V to (V+) + 0.5V
Current[2]	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

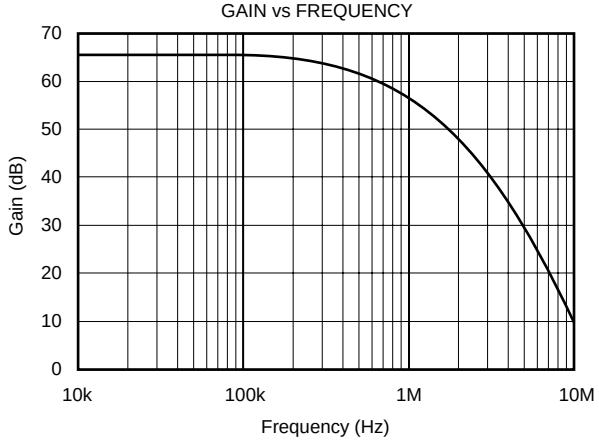
PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER	PACKAGE MARKING	ORDERING NUMBER[1]	TRANSPORT MEDIA
INA166UA	SO-14 Surface Mount	235	INA166UA	INA166UA	Rails
"	"	"	"	INA166UA/2K5	Tape and Reel

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.

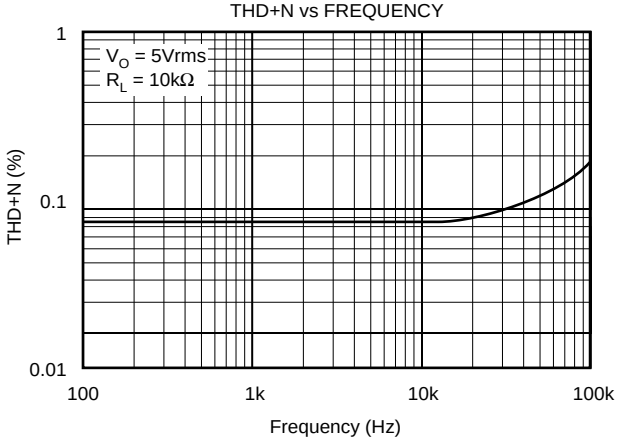
TYPICAL PERFORMANCE CURVES

At T_A = +25°C, V_S = ±5V, R_L = 2kΩ, C_L = 50pF, G = 2000, unless otherwise noted.

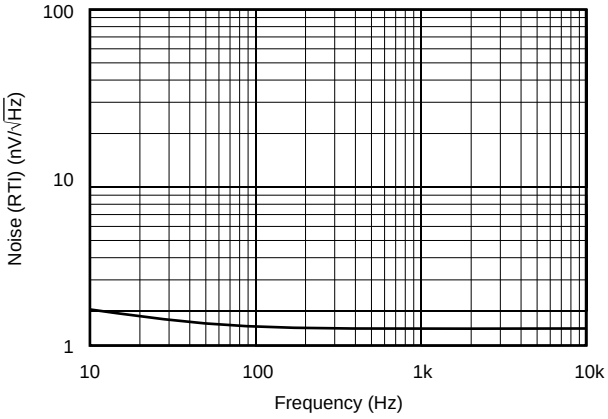
GAIN vs FREQUENCY



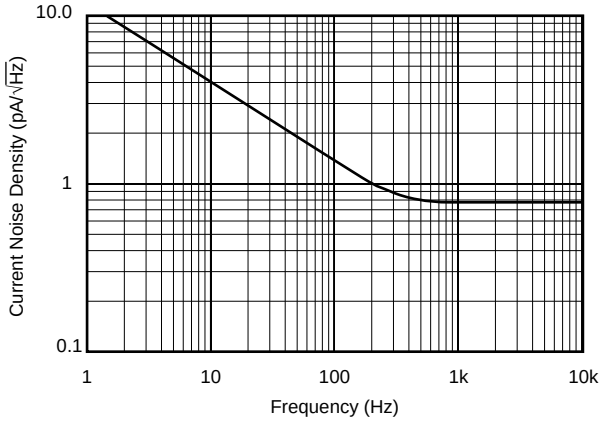
THD+N vs FREQUENCY



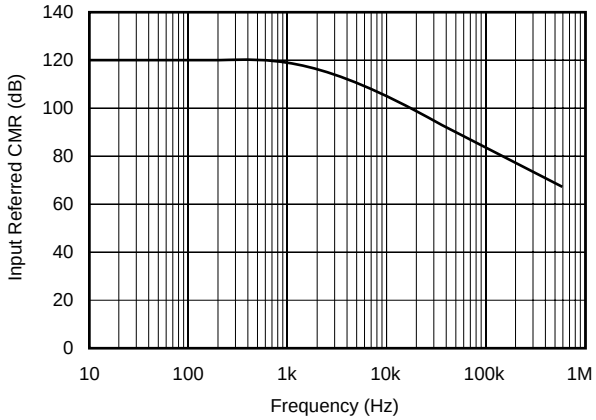
NOISE VOLTAGE (RTI) vs FREQUENCY



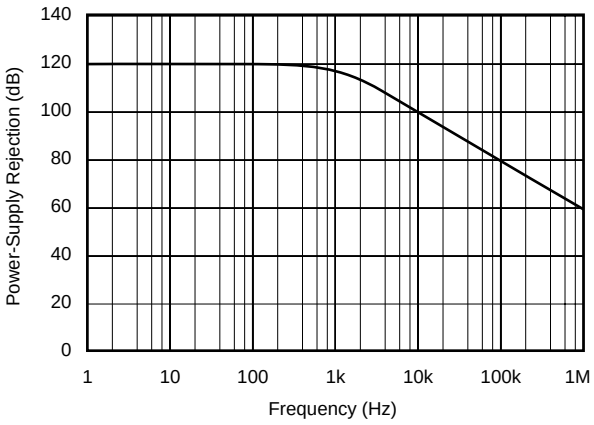
CURRENT NOISE SPECTRAL DENSITY



CMR vs FREQUENCY



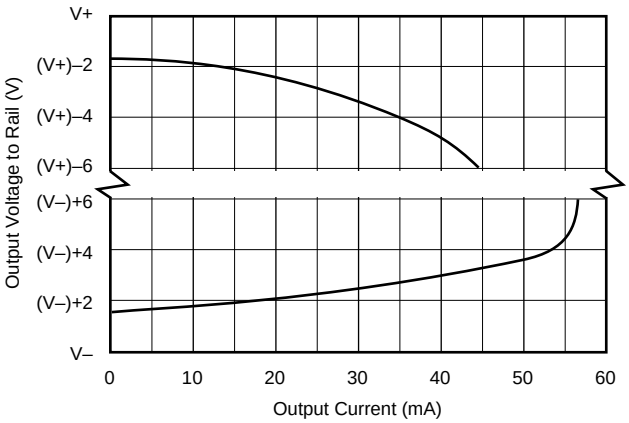
POWER-SUPPLY REJECTION vs FREQUENCY



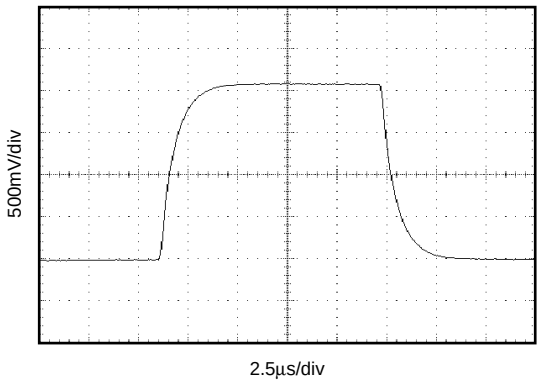
TYPICAL PERFORMANCE CURVES (Cont.)

At T_A = +25°C, V_S = ±5V, R_L = 2kΩ, C_L = 50pF, G = 2000, unless otherwise noted.

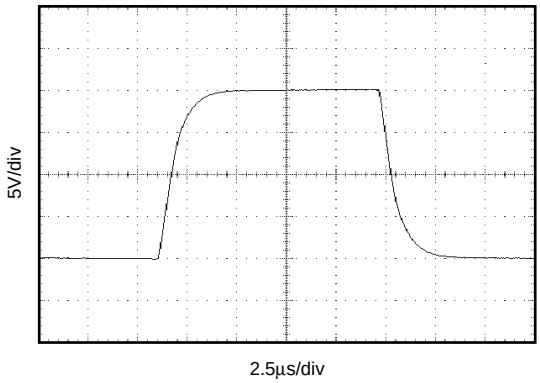
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



SMALL-SIGNAL RESPONSE



LARGE-SIGNAL RESPONSE



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 ±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 ±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 1.3nV/√Hz voltage noise delivers near-theoretical noise performance with a source impedance of 200Ω. 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 10kΩ. For source impedance greater than 10kΩ, other instrumentation amplifiers may provide improved noise performance.

INPUT CONSIDERATIONS

Very low source impedance (less than 10Ω) 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.

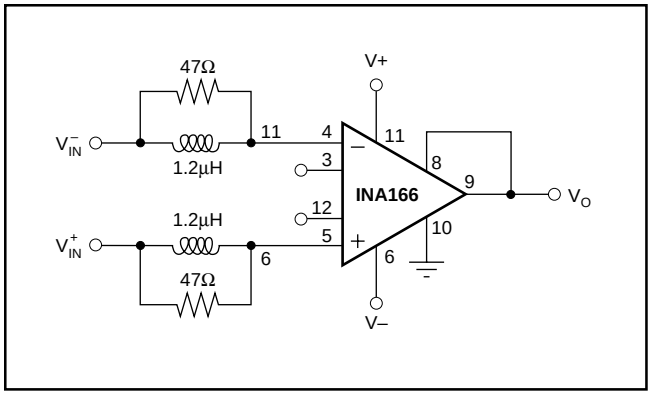


FIGURE 2. Input Stabilization Network.

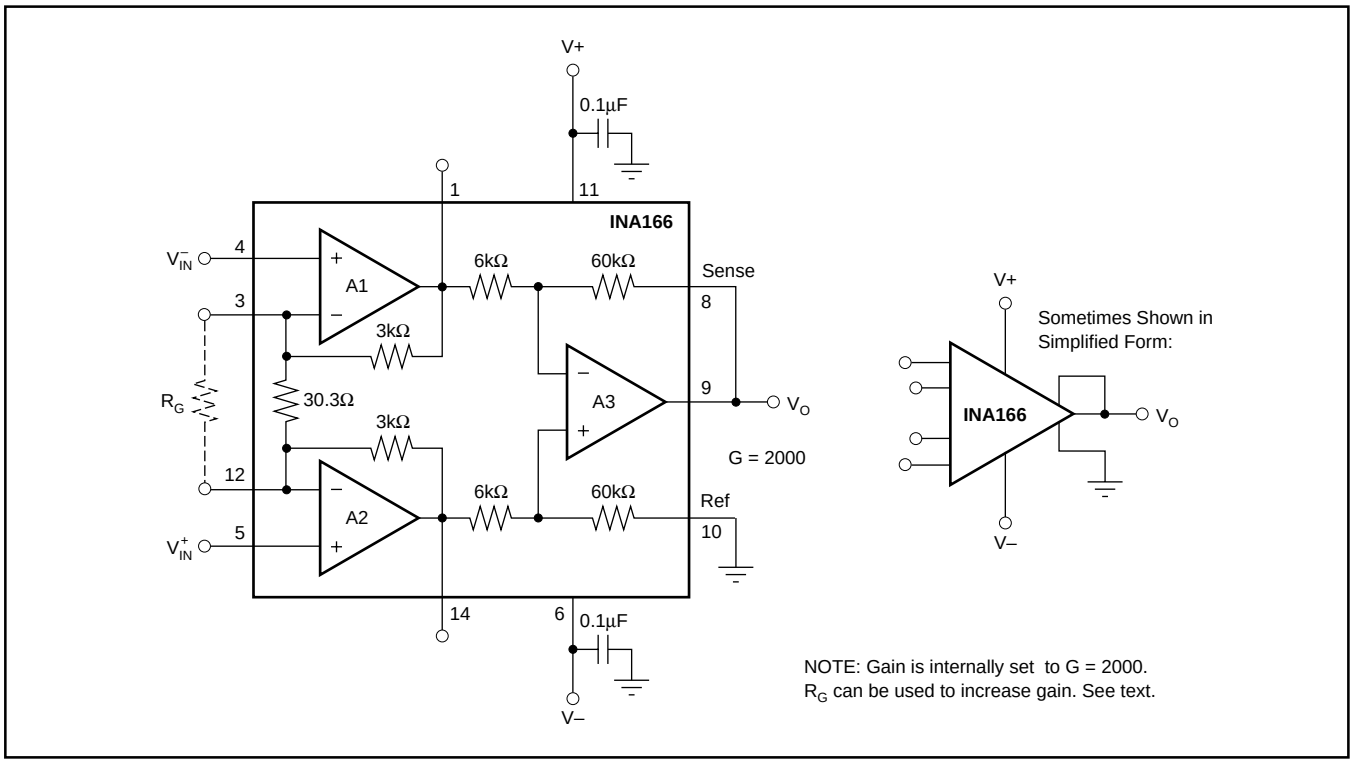


FIGURE 1. Basic Circuit Connections.

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 • 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.

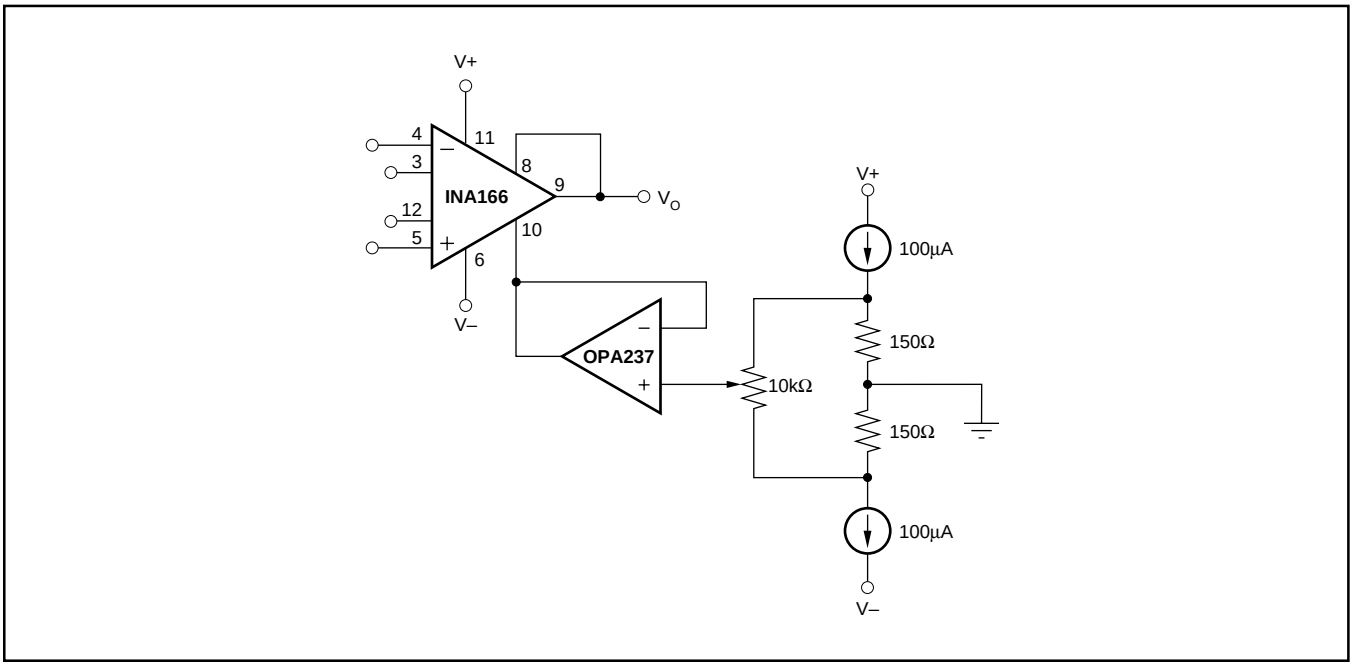


FIGURE 3. Offset Voltage Adjustment Circuit.

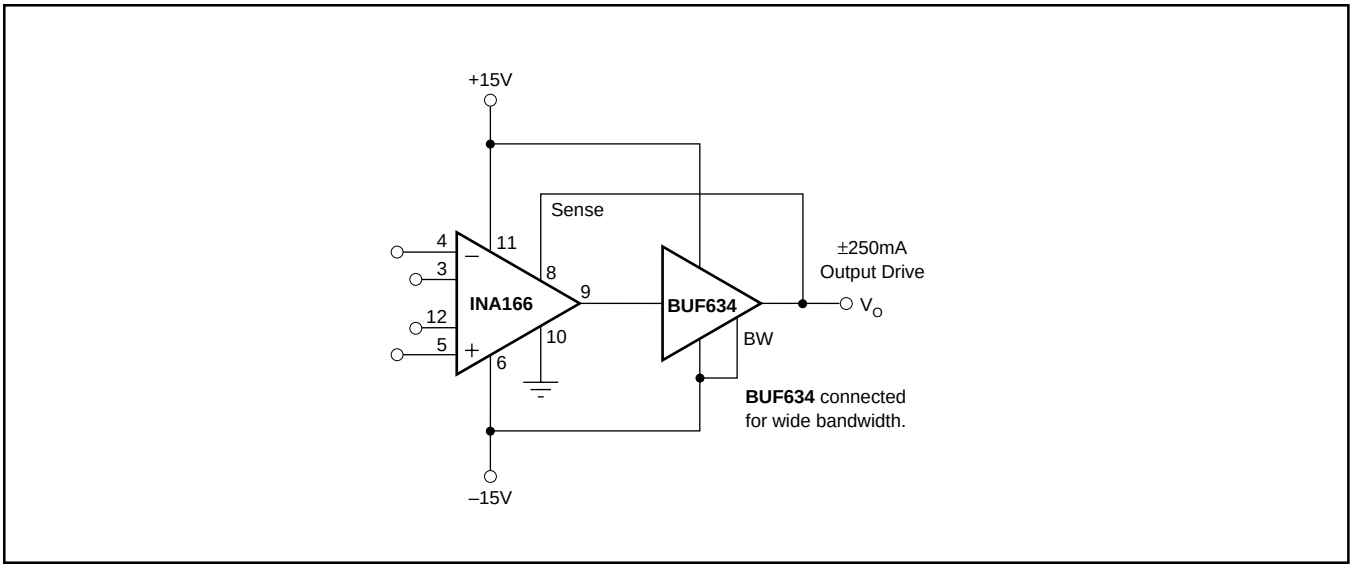


FIGURE 4. Buffer for Increase Output Current.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
INA166UA	Obsolete	Production	SOIC (D) | 14	-	-	Call TI	Call TI	-55 to 125	INA166UA
INA166UA/2K5	Active	Production	SOIC (D) | 14	2500 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-55 to 125	INA166UA
INA166UA/2K5.A	Active	Production	SOIC (D) | 14	2500 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-55 to 125	INA166UA

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

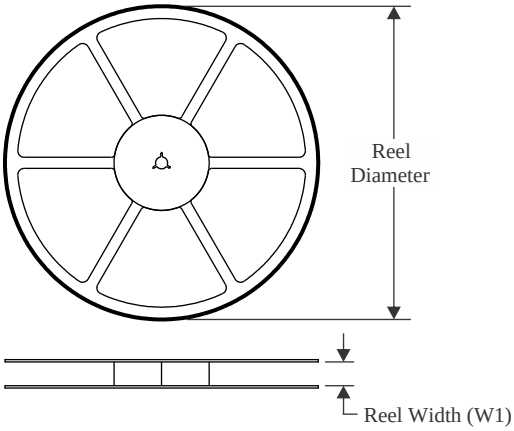
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

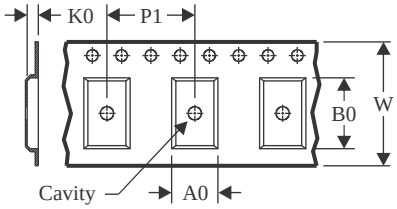
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

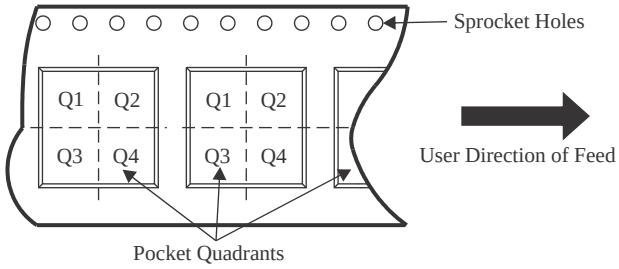


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

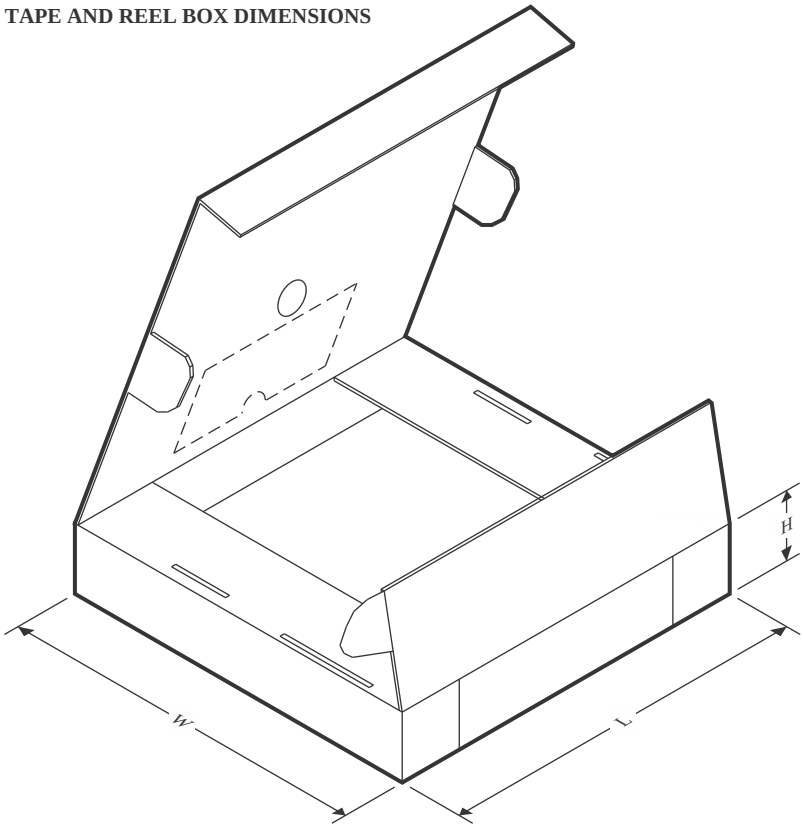
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
INA166UA/2K5	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
INA166UA/2K5	SOIC	D	14	2500	353.0	353.0	32.0

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