



Burr-Brown Products  
from Texas Instruments

INA163



www.ti.com

## Low-Noise, Low-Distortion INSTRUMENTATION AMPLIFIER

### FEATURES

- LOW NOISE:  $1\text{nV}/\sqrt{\text{Hz}}$  at 1kHz
- LOW THD+N: 0.002% at 1kHz,  $G = 100$
- WIDE BANDWIDTH: 800kHz at  $G = 100$
- 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

- PROFESSIONAL MICROPHONE PREAMPS
- MOVING-COIL TRANSDUCER AMPLIFIERS
- DIFFERENTIAL RECEIVERS
- BRIDGE TRANSDUCER AMPLIFIERS

### DESCRIPTION

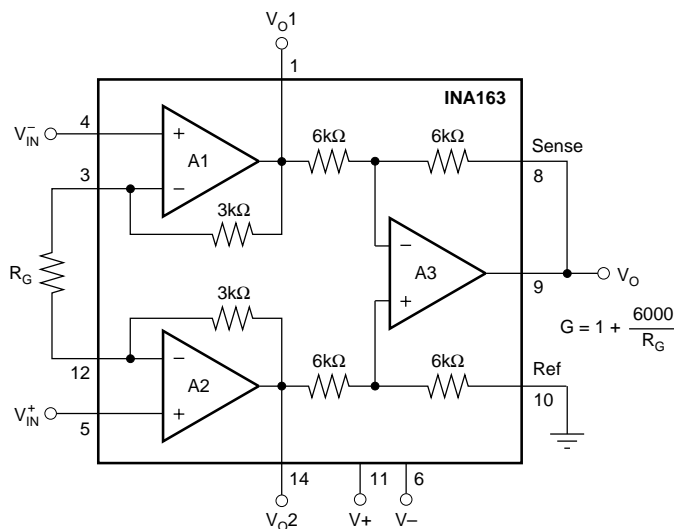
The INA163 is a very low-noise, low-distortion, monolithic instrumentation amplifier. Its current-feedback circuitry achieves very wide bandwidth and excellent dynamic response over a wide range of gain. It is ideal for low-level audio signals such as balanced low-impedance microphones. Many industrial, 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

INA163 provides near-theoretical noise performance for  $200\Omega$  source impedance. Its differential input, low noise, and low distortion provide superior performance in professional microphone amplifier applications.

The INA163's wide supply voltage, excellent output voltage swing, and high output current drive allow its use in high-level audio stages as well.

The INA163 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.



TEXAS  
INSTRUMENTS

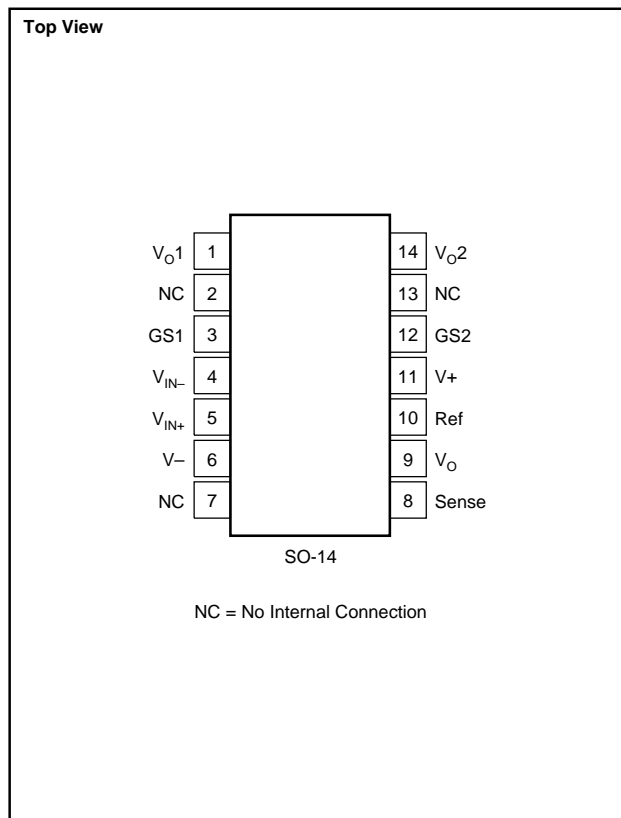
# SPECIFICATIONS: $V_S = \pm 15V$

$T_A = +25^{\circ}C$  and at rated supplies,  $V_S = \pm 15V$ ,  $R_L = 2k\Omega$  connected to ground, unless otherwise noted.

PARAMETER	CONDITIONS	INA163UA			UNITS
		MIN	TYP	MAX	
<b>GAIN</b> Range Gain Equation <sup>(1)</sup> Gain Error, $G = 1$ $G = 10$ $G = 100$ $G = 1000$ Gain Temp Drift Coefficient, $G = 1$ $G > 10$ Nonlinearity, $G = 1$ $G = 100$			1 to 10000 $G = 1 + 6k/R_G$ $\pm 0.1$ $\pm 0.2$ $\pm 0.2$ $\pm 0.5$ $\pm 1$ $\pm 25$ $\pm 0.0003$ $\pm 0.0006$	$\pm 0.25$ $\pm 0.7$   $\pm 10$ $\pm 100$	V/V % % % % ppm/ $^{\circ}C$ ppm/ $^{\circ}C$ % of FS % of FS
<b>INPUT STAGE NOISE</b> Voltage Noise $f_O = 1kHz$ $f_O = 100Hz$ $f_O = 10Hz$ Current Noise $f_O = 1kHz$	$R_{SOURCE} = 0\Omega$		1 1.2 2  0.8		nV/ $\sqrt{Hz}$ nV/ $\sqrt{Hz}$ nV/ $\sqrt{Hz}$  pA/ $\sqrt{Hz}$
<b>OUTPUT STAGE NOISE</b> Voltage Noise, $f_O = 1kHz$			60		nV/ $\sqrt{Hz}$
<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 $\pm 18V$		$50 + 2000/G$ $1 + 20/G$ $1 + 50/G$	$250 + 5000/G$  $3 + 200/G$	$\mu V$ $\mu V/^{\circ}C$ $\mu V/V$
<b>INPUT VOLTAGE RANGE</b> Common-Mode Voltage Range  Common-Mode Rejection, $G = 1$ $G = 100$	$V_{IN+} - V_{IN-} = 0V$ $V_{IN+} - V_{IN-} = 0V$ $V_{CM} = \pm 11V$ , $R_{SRC} = 0\Omega$	(V+) – 4 (V–) + 4 70 100	(V+) – 3 (V–) + 3 80 116		V V dB dB
<b>INPUT BIAS CURRENT</b> Initial Bias Current vs Temperature Initial Offset Current vs Temperature			2 10 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, $G = 1$ $G = 100$  Slew Rate THD+Noise, $f = 1kHz$ Settling Time, 0.1% 0.01% Overload Recovery	     $G = 100$ $G = 100$ , 10V Step $G = 100$ , 10V Step 50% Overdrive		3.4 800 15 0.002 2 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 Gnd  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	   $I_O = 0mA$	$\pm 4.5$	$\pm 15$  $\pm 10$	$\pm 18$  $\pm 12$	V V mA
<b>TEMPERATURE RANGE</b> Specification Operating $\theta_{JA}$		–40 –40	  100	+85 +125	$^{\circ}C$ $^{\circ}C$ $^{\circ}C/W$

NOTE: (1) Gain accuracy is a function of external  $R_G$ .

## 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 <sub>-</sub> ) - 0.5V to (V <sub>+</sub> ) + 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.

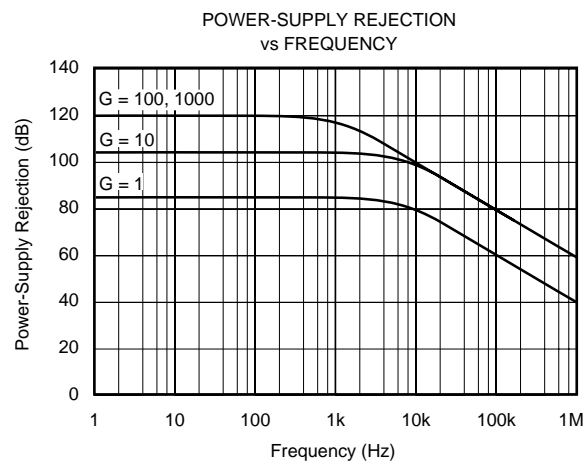
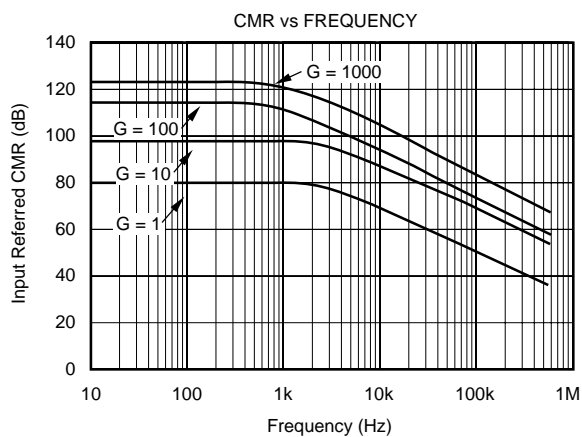
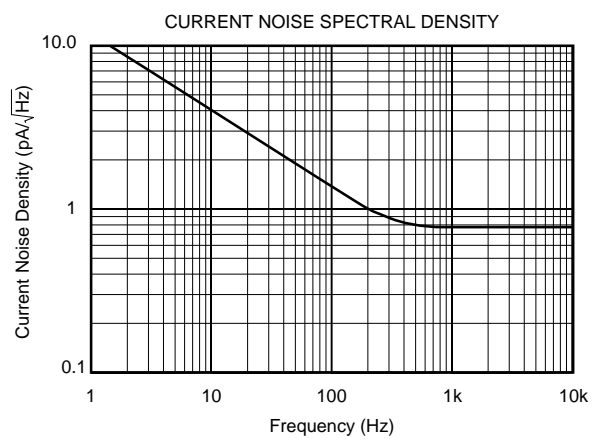
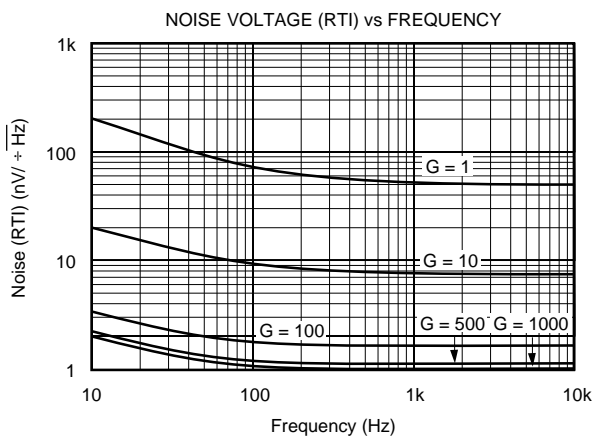
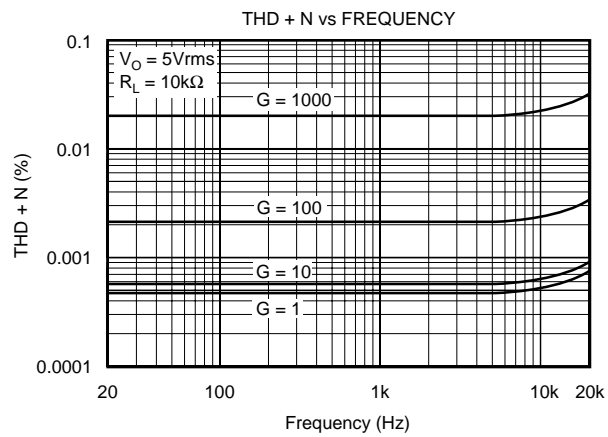
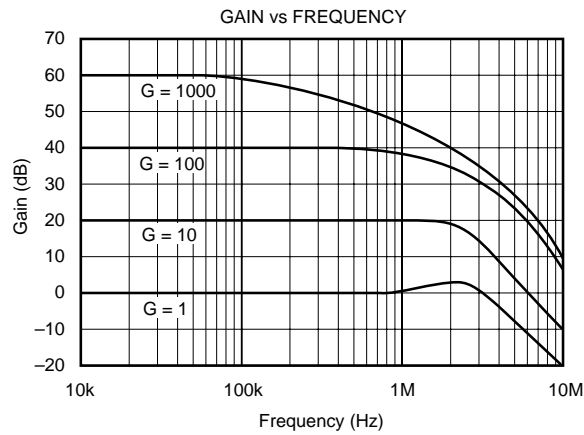
## PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER	PACKAGE MARKING	ORDERING NUMBER <sup>(1)</sup>	TRANSPORT MEDIA
INA163UA "	SO-14 Surface Mount "	235 "	INA163UA "	INA163 INA163UA/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 "INA163UA/2K5" will get a single 2500-piece Tape and Reel.

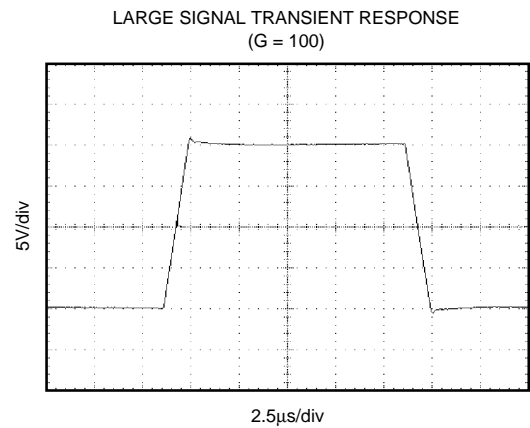
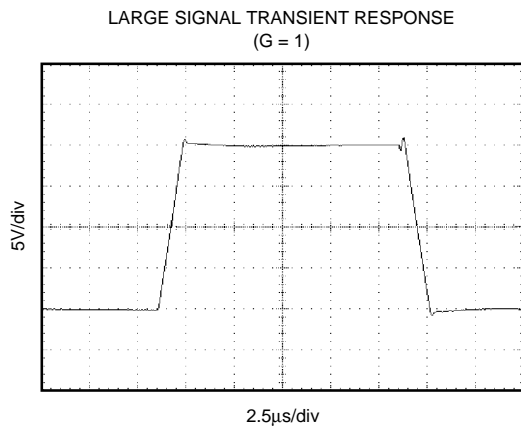
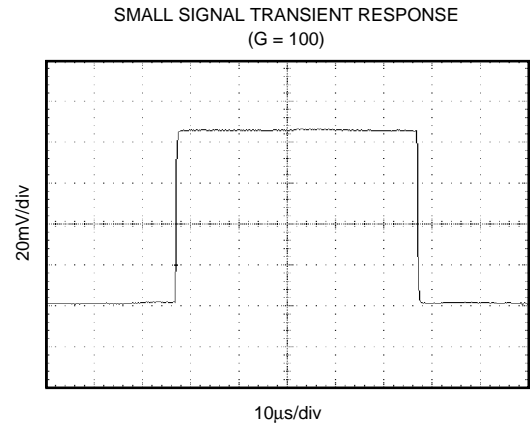
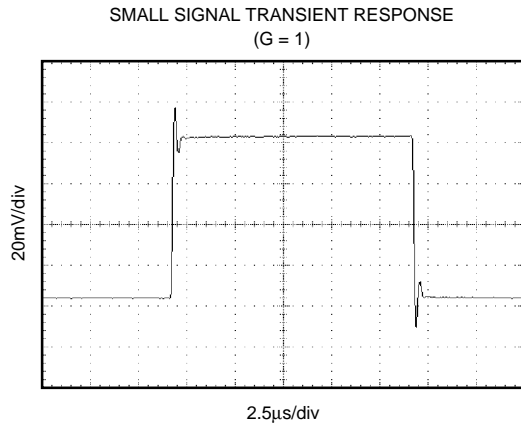
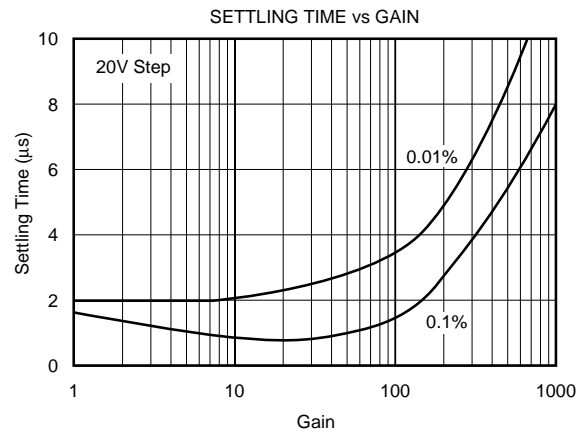
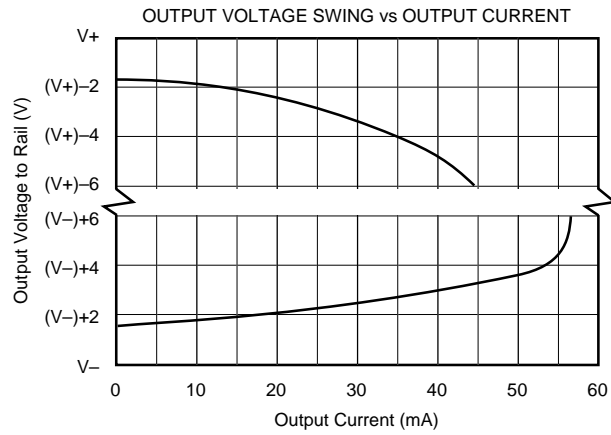
# TYPICAL PERFORMANCE CURVES

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $V_{CM} = 1/2 V_S$ ,  $R_L = 25\text{k}\Omega$ ,  $C_L = 50\text{pF}$ , unless otherwise noted.



# TYPICAL PERFORMANCE CURVES (Cont.)

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $V_{CM} = 1/2 V_S$ ,  $R_L = 25\text{k}\Omega$ ,  $C_L = 50\text{pF}$ , 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 a few ohms in series with these connections will degrade the common-mode rejection of the INA163.

## GAIN-SET RESISTOR

Gain is set with an external resistor,  $R_G$ , as shown in Figure 1. The two internal 3kΩ feedback resistors are laser-trimmed to 3kΩ within approximately ±0.2%. Gain is:

$$G = 1 + \frac{6000}{R_G}$$

The temperature coefficient of the internal 3kΩ resistors is approximately ±25ppm/°C. Accuracy and TCR of the exter-

nal  $R_G$  will also contribute to gain error and temperature drift. These effects can be inferred from the gain equation. Make a short, direct connection to the gain set resistor,  $R_G$ . Avoid running output signals near these sensitive input nodes.

## NOISE PERFORMANCE

The INA163 provides very low-noise with low-source impedance. Its 1nV/√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 INA163 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.

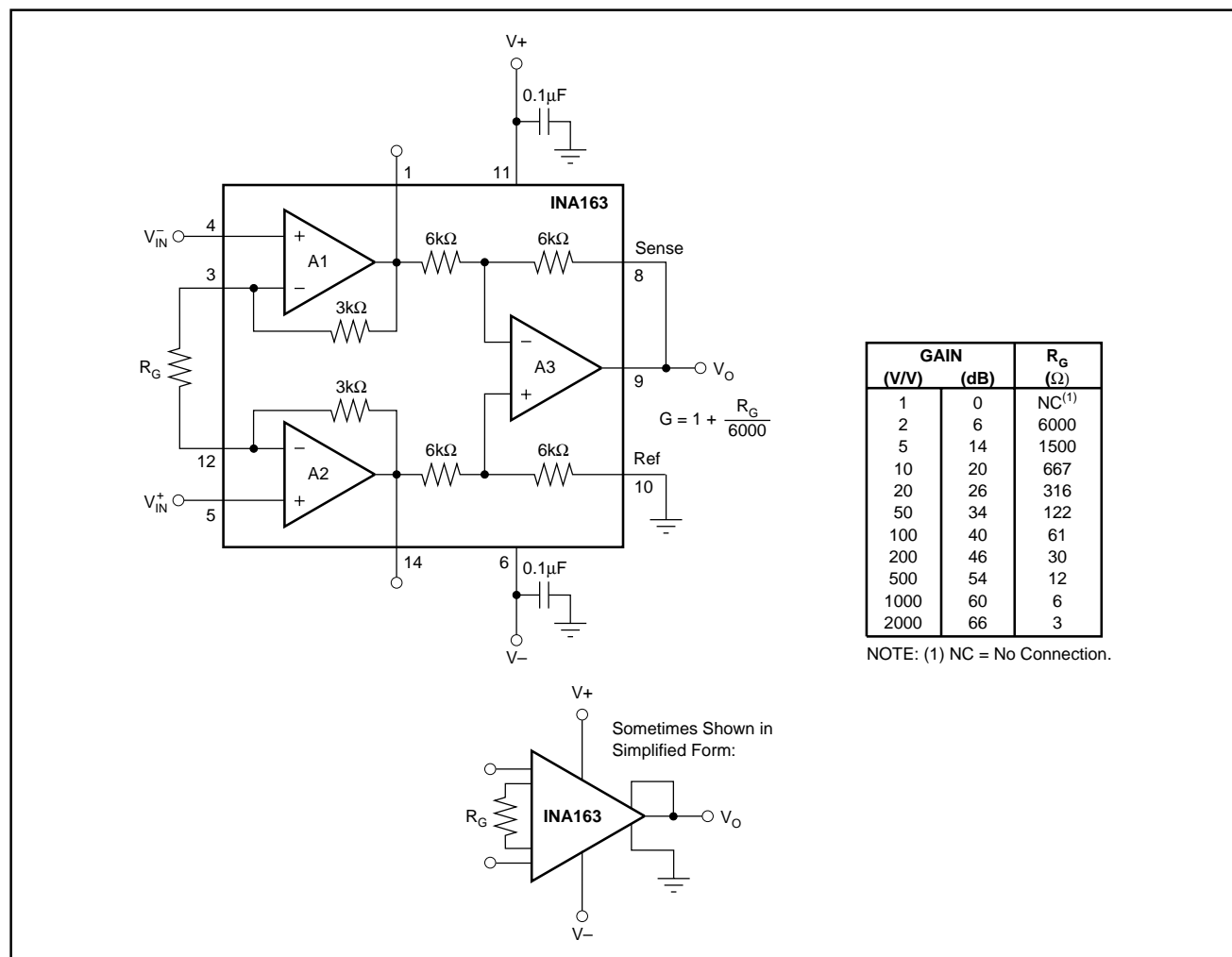


FIGURE 1. Basic Circuit Connections.

## INPUT CONSIDERATIONS

Very low source impedance (less than  $10\Omega$ ) can cause the INA163 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 INA163. Although not shown in other figures, this network can be used as needed with all applications shown.

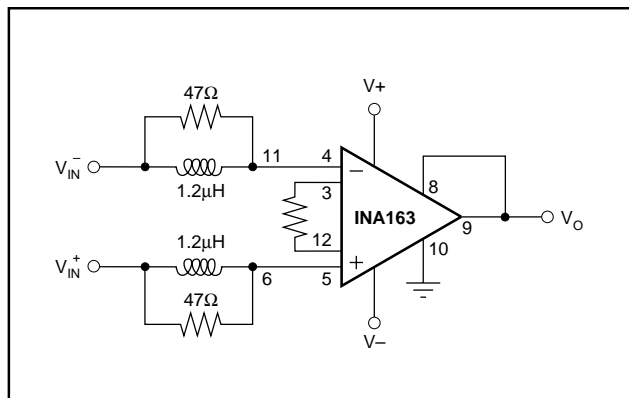


FIGURE 2. Input Stabilization Network.

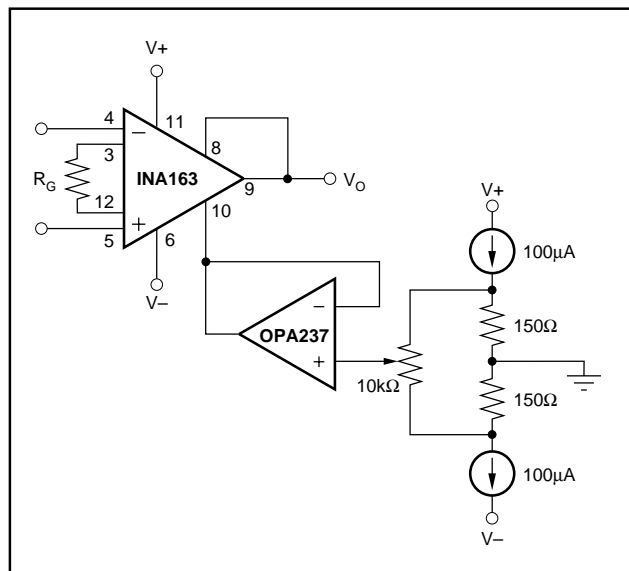


FIGURE 3. Offset Voltage Adjustment Circuit.

## 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.

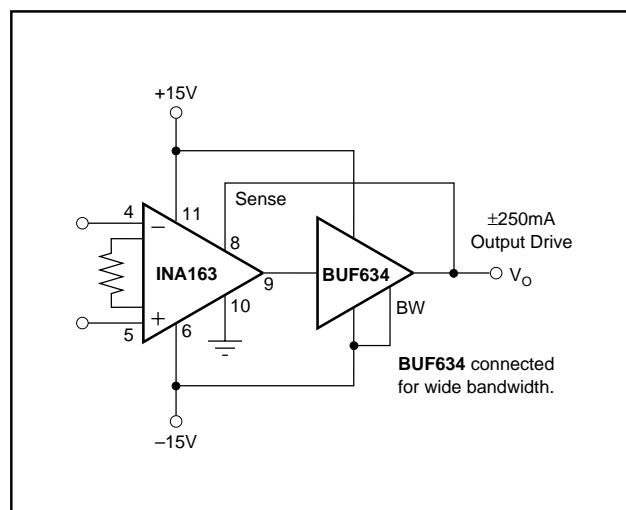


FIGURE 4. Buffer for Increase Output Current.

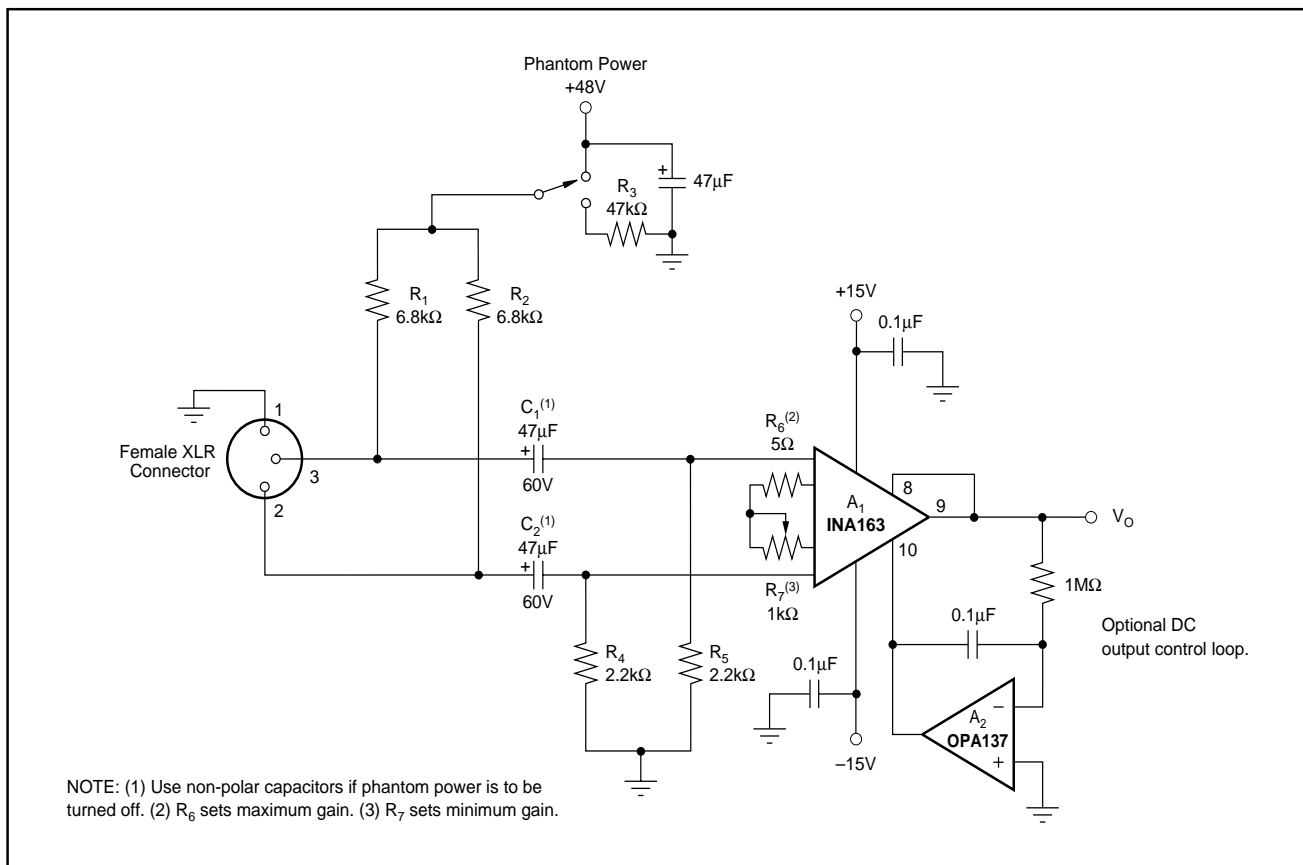


FIGURE 5. Phantom-Powered Microphone Preamplifier.

## MICROPHONE AMPLIFIER

Figure 5 shows a typical circuit for a professional microphone input amplifier.  $R_1$  and  $R_2$  provide a current path for conventional 48V phantom power source for a remotely located microphone. An optional switch allows phantom power to be disabled.  $C_1$  and  $C_2$  block the phantom power voltage from the INA163 input circuitry. Non-polarized capacitors should be used for  $C_1$  and  $C_2$  if phantom power is to be disabled.

$R_4$  and  $R_5$  provide a path for input bias current of the INA163. Input offset current (typically 100nA) creates a DC differential input voltage that will produce an output offset voltage. This is generally the dominant source of output

offset voltage in this application. With a maximum gain of 1000 (60dB), the output offset voltage can be several volts. This may be entirely acceptable if the output is AC-coupled into the subsequent stage. An alternate technique is shown in Figure 5. An inexpensive FET-input op amp in a feedback loop drives the DC output voltage to 0V.  $A_2$  is not in the audio signal path and does not affect signal quality.

Gain is set with a variable resistor,  $R_7$ , in series with  $R_6$ .  $R_6$  determines the maximum gain. The total resistance,  $R_6 + R_7$ , determines the lowest gain. A special reverse-log taper potentiometer for  $R_7$  can be used to create a linear change (in dB) with rotation.



## **IMPORTANT NOTICE**

Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgment, including those pertaining to warranty, patent infringement, and limitation of liability.

TI warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

Customers are responsible for their applications using TI components.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. 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 of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI's publication of information regarding any third party's products or services does not constitute TI's approval, warranty or endorsement thereof.