



# INA157

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## High-Speed, Precision DIFFERENCE AMPLIFIER

### FEATURES

- DESIGNED FOR LOW COST
- LOW OFFSET VOLTAGE:  $\pm 500\mu\text{V}$  max
- LOW OFFSET DRIFT:  $\pm 2\mu\text{V}/^\circ\text{C}$
- LOW GAIN ERROR:  $\pm 0.05\%$  max
- WIDE BANDWIDTH: 3MHz
- HIGH SLEW RATE:  $14\text{V}/\mu\text{s}$
- FAST SETTLING TIME:  $3\mu\text{s}$  to 0.01%
- WIDE SUPPLY RANGE:  $\pm 4\text{V}$  to  $\pm 18\text{V}$
- LOW QUIESCENT CURRENT: 2.4mA
- SO-8 SURFACE-MOUNT PACKAGE

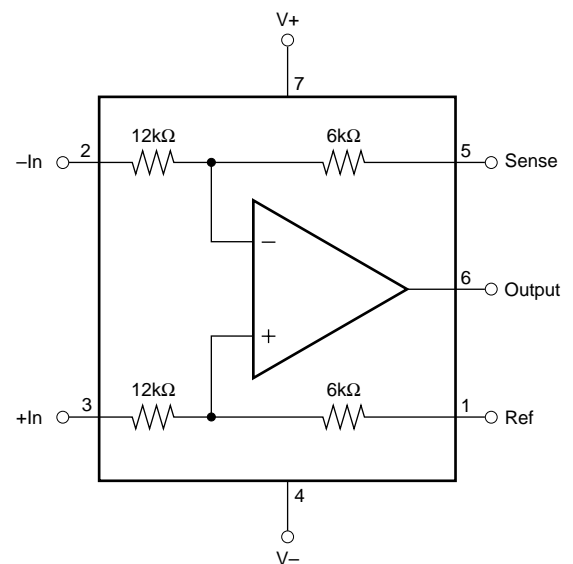
### APPLICATIONS

- DIFFERENTIAL INPUT AMPLIFIER
- INSTRUMENTATION AMPLIFIER BUILDING BLOCK
- $G = 1/2$  AMPLIFIER
- $G = 2$  AMPLIFIER
- DIFFERENTIAL CURRENT RECEIVER
- VOLTAGE-CONTROLLED CURRENT SOURCE
- GROUND LOOP ELIMINATOR
- CURRENT SHUNT MONITOR

### DESCRIPTION

The INA157 is a high slew rate,  $G = 1/2$  or  $G = 2$  difference amplifier consisting of a precision op amp with a precision resistor network. The on-chip resistors are laser trimmed for accurate gain and high common-mode rejection. Excellent TCR tracking of the resistors maintains gain accuracy and common-mode rejection over temperature. The input common-mode voltage range extends beyond the positive and negative supply rails. It operates on  $\pm 4\text{V}$  to  $\pm 18\text{V}$  supplies.

The difference amplifier is the foundation of many commonly used circuits. The INA157 provides this circuit function without using an expensive precision resistor network. The INA157 is available in a SO-8 surface-mount package and is specified for operation over the extended industrial temperature range,  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$ .



# SPECIFICATIONS: $V_S = \pm 15V$

At  $T_A = +25^\circ C$ ,  $V_S = \pm 15V$ ,  $R_L = 2k\Omega$  connected to ground, and reference pin connected to ground, unless otherwise noted.

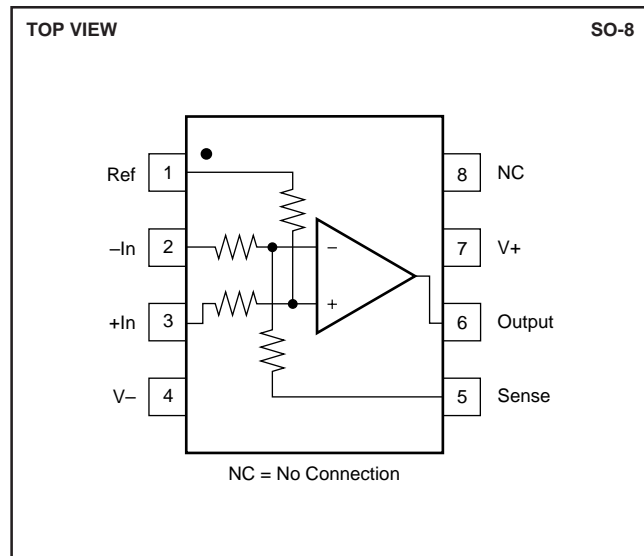
PARAMETER	CONDITIONS	INA157U			INA157UA			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
<b>OFFSET VOLTAGE<sup>(1)</sup></b> Initial <sup>(1)</sup> vs Temperature vs Power Supply vs Time	RTO  $V_S = \pm 4V$ to $\pm 18V$		$\pm 100$ $\pm 2$ $\pm 5$ 0.25	$\pm 500$ $\pm 20$ $\pm 60$		*	$\pm 1000$ * *	$\mu V$ $\mu V/^\circ C$ $\mu V/V$ $\mu V/mo$
<b>INPUT IMPEDANCE<sup>(2)</sup></b> Differential Common-Mode			24 18			*		k $\Omega$ k $\Omega$
<b>INPUT VOLTAGE RANGE</b> Common-Mode Voltage Range Positive Negative Common-Mode Rejection Ratio	$V_O = 0V$ $V_O = 0V$ $V_{CM} = -37.5V$ to $37.5V$ , $R_S = 0\Omega$	$3(V+) - 7.5$ $3(V-) + 7.5$ 86	$3(V+) - 6$ $3(V-) + 3$ 96		*	*	*	V V dB
<b>OUTPUT VOLTAGE NOISE<sup>(3)</sup></b> $f = 0.1Hz$ to $10Hz$ $f = 1kHz$	RTO		1.3 26			*		$\mu Vp-p$ nV/ $\sqrt{Hz}$
<b>GAIN</b> Initial Error vs Temperature Nonlinearity	$V_O = -10V$ to $+10V$  $V_O = -10V$ to $+10V$		0.5 $\pm 0.01$ $\pm 1$ $\pm 0.0001$	$\pm 0.05$ $\pm 10$ $\pm 0.001$		*	*	V/V % ppm/ $^\circ C$ % of FS
<b>OUTPUT</b> Voltage, Positive Negative Current Limit, Continuous to Common Capacitive Load (stable operation)		$(V+) - 2$ $(V-) + 2$	$(V+) - 1.8$ $(V-) + 1.6$ $\pm 60$ 500		*	*	*	V V mA pF
<b>FREQUENCY RESPONSE</b> Small-Signal Bandwidth Slew Rate Settling Time: 0.1% 0.01% Overload Recovery Time	-3dB  10V Step, $C_L = 100pF$ 10V Step, $C_L = 100pF$ 50% Overdrive		4 14 2 3 3			*	*	MHz V/ $\mu s$ $\mu s$ $\mu s$ $\mu s$
<b>POWER SUPPLY</b> Rated Voltage Operating Voltage Range Quiescent Current	  $I_O = 0mA$		$\pm 4$  $\pm 2.4$	$\pm 15$  $\pm 18$  $\pm 2.9$		*	*	V V mA
<b>TEMPERATURE RANGE</b> Specified Operation Storage Thermal Resistance, $\theta_{JA}$ SO-8 Surface-Mount		-40 -55 -55		+85 +125 +125	*		*	$^\circ C$ $^\circ C$ $^\circ C$ $^\circ C/W$

\*Specifications the same as INA157U.

NOTES: (1) Includes effects of amplifier's input bias and offset currents. (2) Internal resistors are ratio matched but have  $\pm 20\%$  absolute value. (3) Includes effects of amplifier's input current noise and thermal noise contribution of resistor network.

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## PIN CONFIGURATION



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

Supply Voltage, V+ to V-	40V
Input Voltage Range	±80V
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

NOTE: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability.



## 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.

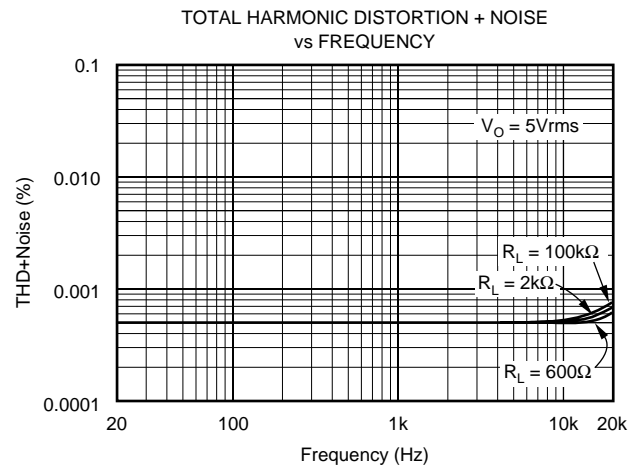
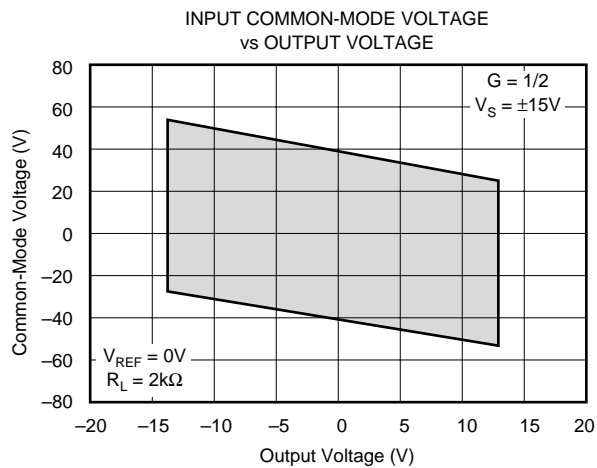
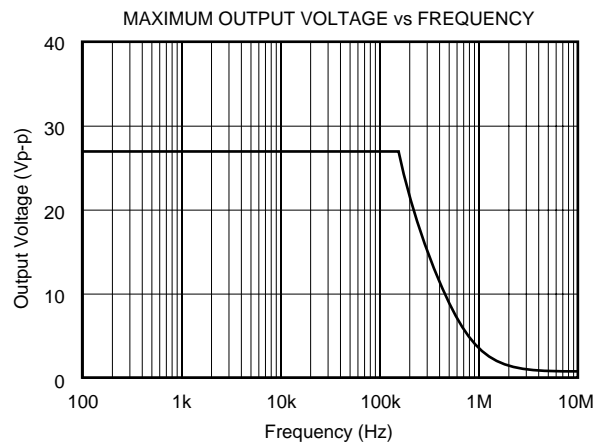
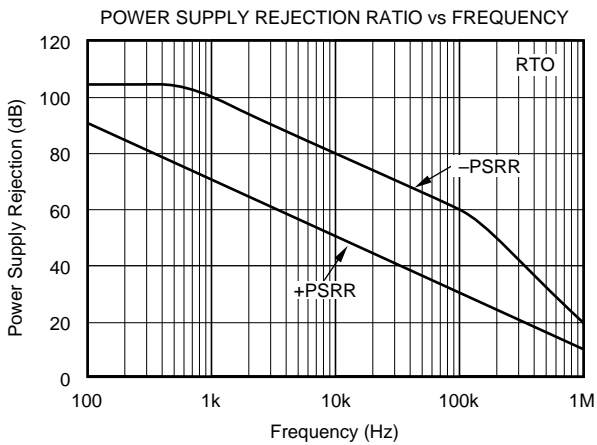
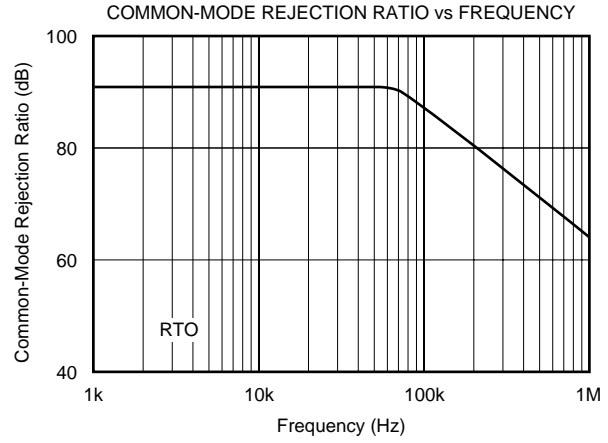
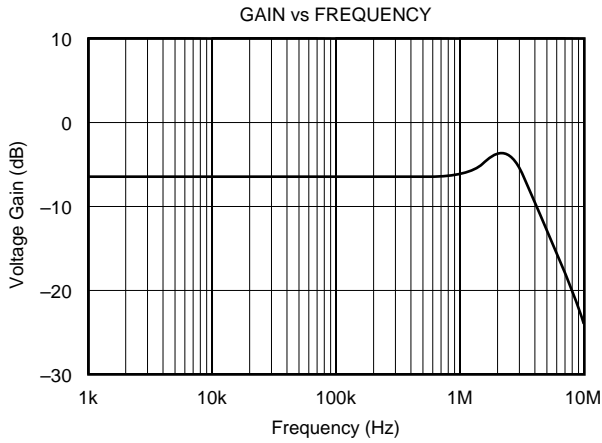
## PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER <sup>(1)</sup>	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER <sup>(2)</sup>	TRANSPORT MEDIA
INA157U	SO-8 Surface-Mount	182	-40°C to +85°C	INA157U	INA157U	Rails
"	"	"	"	"	INA157U/2K5	Tape and Reel
INA157UA	SO-8 Surface-Mount	182	-40°C to +85°C	INA157UA	INA157UA	Rails
"	"	"	"	"	INA157UA/2K5	Tape and Reel

NOTES: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book. (2) 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 "INA157U/2K5" will get a single 2500-piece Tape and Reel. For detailed Tape and Reel mechanical information, refer to Appendix B of Burr-Brown IC Data Book.

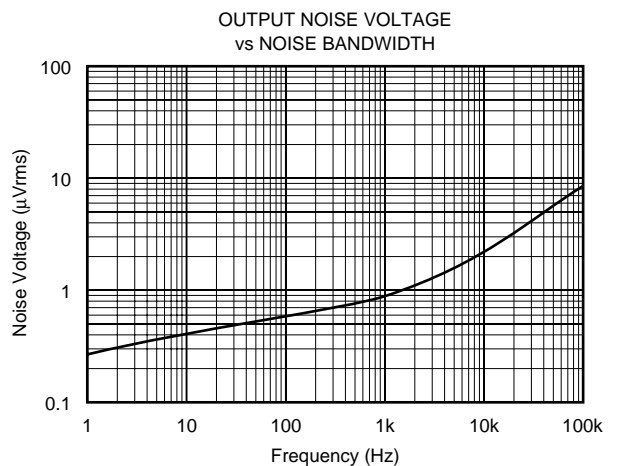
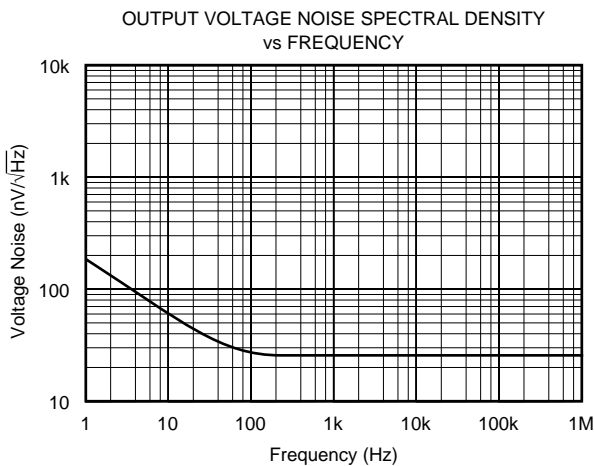
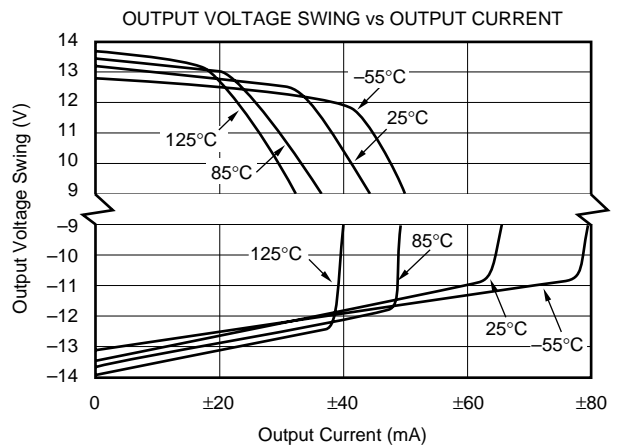
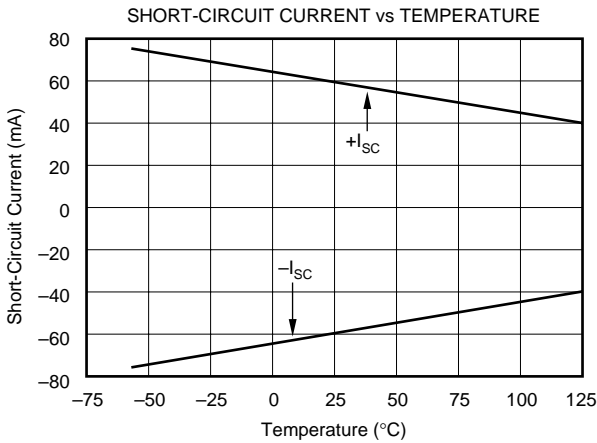
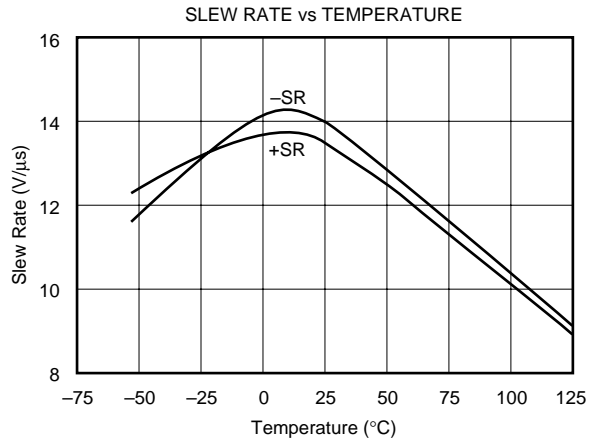
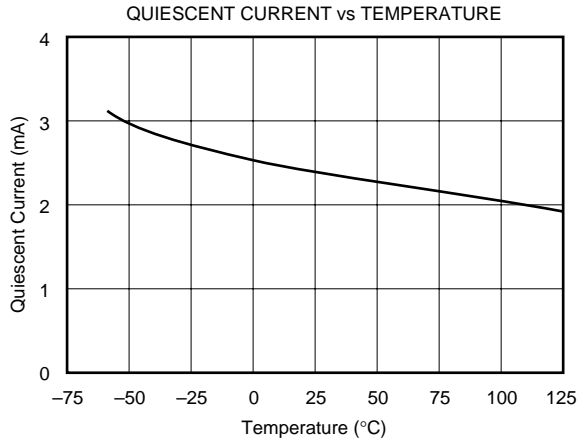
# TYPICAL PERFORMANCE CURVES

At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 15\text{V}$ , and  $G = 1/2$ , unless otherwise noted.



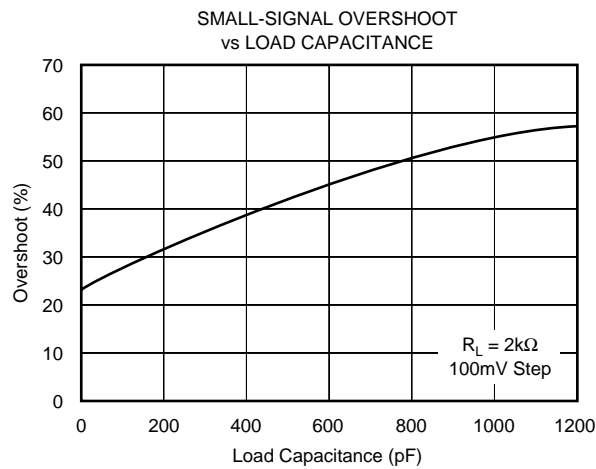
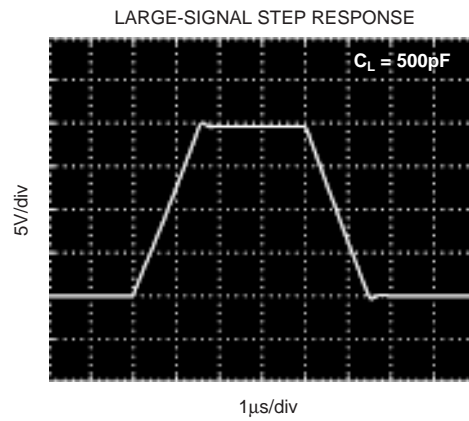
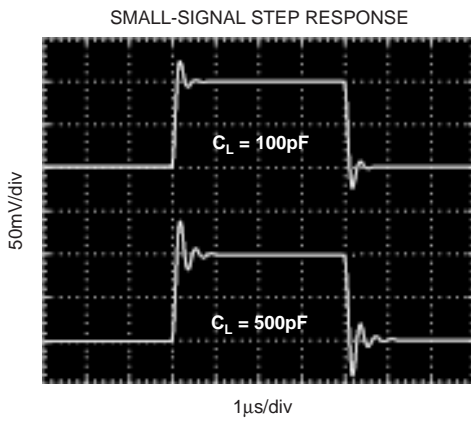
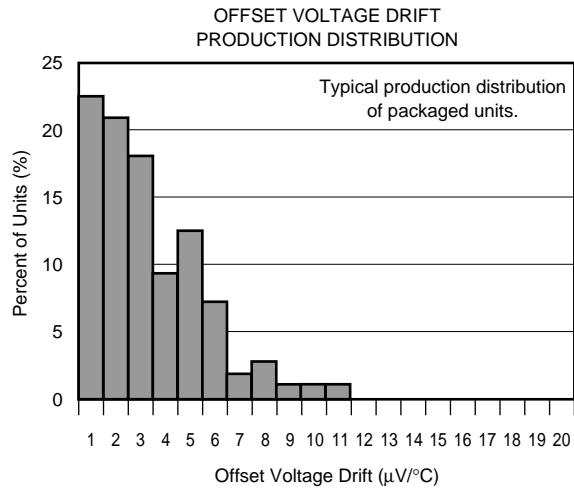
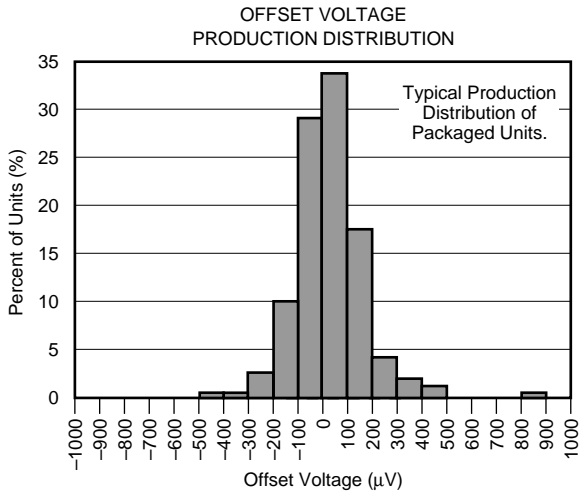
# TYPICAL PERFORMANCE CURVES (CONT)

At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 15\text{V}$ , and  $G = 1/2$ , unless otherwise noted.



# TYPICAL PERFORMANCE CURVES (CONT)

At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 15\text{V}$ , and  $G = 1/2$ , unless otherwise noted.



## APPLICATIONS INFORMATION

The INA157 is a difference amplifier suitable for a wide range of general-purpose applications. Figure 1 shows the basic  $G = 1/2$  configuration. The input and feedback resistors can be reversed to achieve  $G = 2$ , as shown in Figure 2. For applications requiring  $G = 1$ , the INA154 is recommended.

Decoupling capacitors are strongly recommended for applications with noisy or high impedance power supplies. The capacitors should be placed close to the device pins as shown in Figure 1.

As shown in Figure 1, the output is referred to the reference terminal (pin 1). A voltage applied to this pin will be summed with the output signal. The differential input signal is connected to pins 2 and 3. The source impedances connected to the inputs must be nearly equal to assure good common-mode rejection. A  $5\Omega$  mismatch in source impedance will degrade the common-mode rejection of a typical device to approximately 77dB (RTO). If the source has a known impedance mismatch, an additional resistor in series with the opposite input can be used to preserve good common-mode rejection.

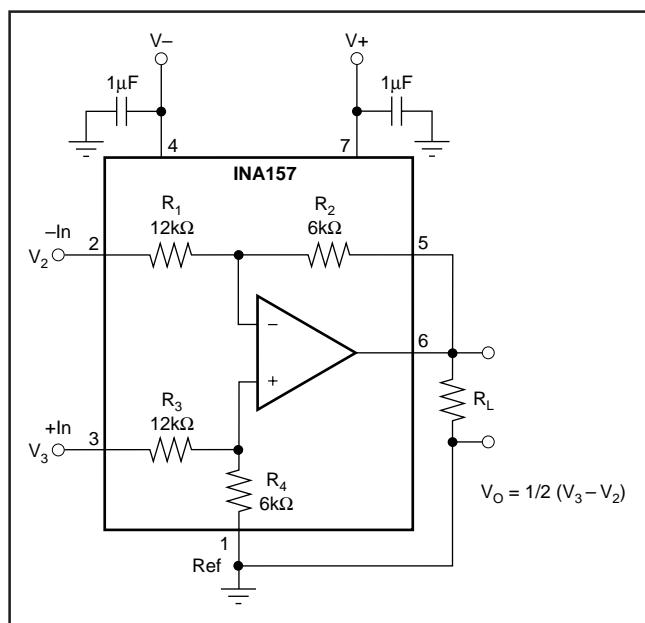


FIGURE 1.  $G = 1/2$  Differential Amplifier (basic power supply and signal connections).

### OPERATING VOLTAGE

The INA157 operates from  $\pm 4V$  to  $\pm 18V$  supplies with excellent performance. Most behavior remains unchanged throughout the full operating voltage range. Parameters which vary significantly with operating voltage are shown in the Typical Performance Curves.

### INPUT VOLTAGE RANGE

The INA157 can accurately measure differential signals that are above the positive or negative power supply rail. In a gain of  $1/2$ , the linear common-mode range extends from  $3 \cdot (V+) - 7.5V$  to  $3 \cdot (V-) + 7.5V$ . See the Typical Performance Curve, "Input Common-Mode Range vs Output Voltage."

### OFFSET VOLTAGE TRIM

The INA157 is laser trimmed for low offset voltage and drift. Most applications require no external offset adjustment. Figure 3 shows an optional circuit for trimming the output offset voltage. The output is referred to the output reference terminal (pin 1), which is normally grounded. A voltage applied to the Ref terminal will be summed with the output signal. This can be used to null offset voltage as shown in Figure 3. The source impedance of a signal applied to the Ref terminal should be less than  $10\Omega$  to maintain good common-mode rejection.

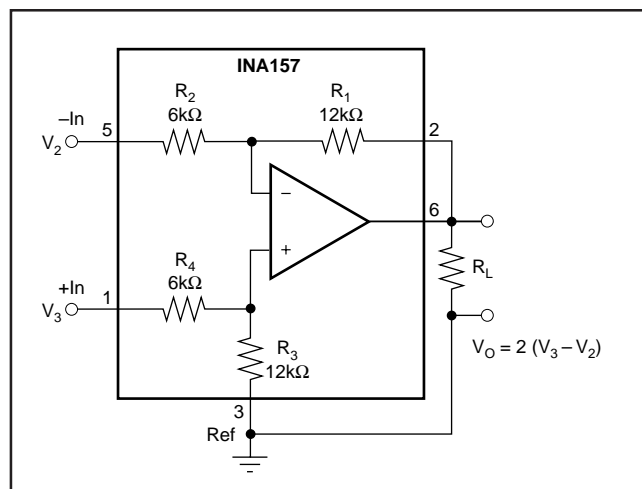


FIGURE 2.  $G = 2$  Differential Amplifier.

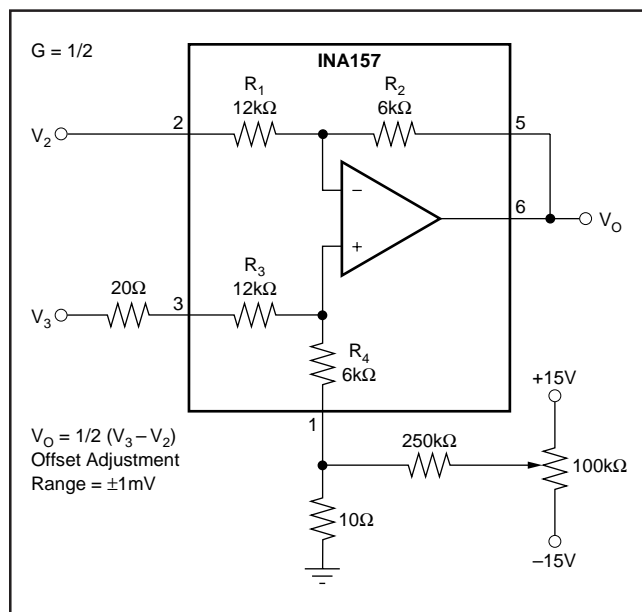


FIGURE 3. Offset Adjustment.

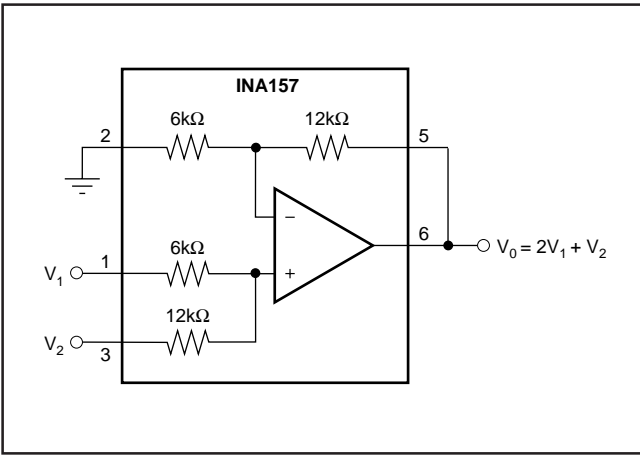


FIGURE 4. Precision Summing Amplifier.

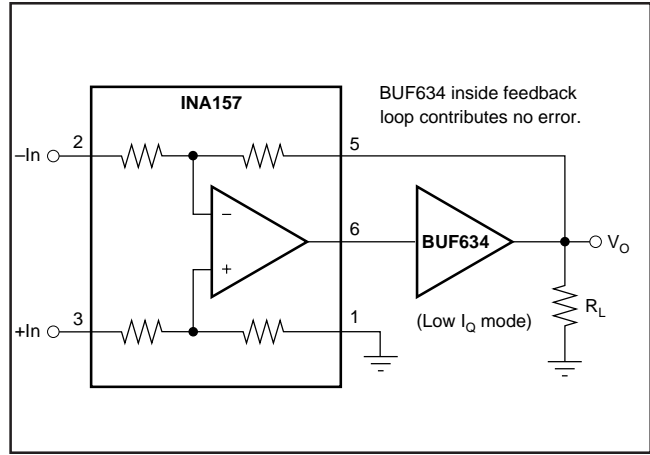


FIGURE 6. Boosting Output Current.

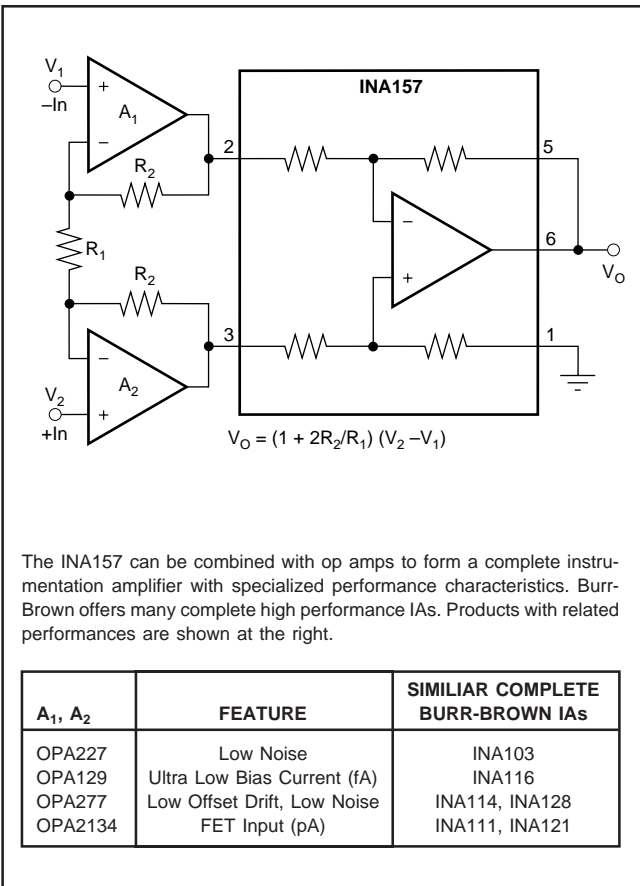


FIGURE 5. Precision Instrumentation Amplifier.

The difference amplifier is a highly versatile building block that is useful in a wide variety of applications. See the INA105 data sheet for additional applications ideas, including:

- Current Receiver with Compliance to Rails
- $\pm 10V$  Precision Voltage Reference
- $\pm 5V$  Precision Voltage Reference
- Precision Average Value Amplifier
- Precision Bipolar Offsetting
- Precision Summing Amplifier with Gain
- Instrumentation Amplifier Guard Drive Generator
- Precision Summing Instrumentation Amplifier
- Precision Absolute Value Buffer
- Precision Voltage-to-Current Converter with Differential Inputs
- Differential Input Voltage-to-Current Converter for Low  $I_{OUT}$
- Isolating Current Source
- Differential Output Difference Amplifier
- Isolating Current Source with Buffering Amplifier for Greater Accuracy
- Window Comparator with Window Span and Window Center Inputs
- Precision Voltage-Controlled Current Source with Buffered Differential Inputs and Gain
- Digitally Controlled Gain of  $\pm 1$  Amplifier



**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
INA157U	ACTIVE	SOIC	D	8	75	RoHS & Green	Call TI	Level-3-260C-168 HR	-40 to 85	INA 157U	<a href="#">Samples</a>
INA157U/2K5	ACTIVE	SOIC	D	8	2500	RoHS & Green	Call TI	Level-3-260C-168 HR		INA 157U	<a href="#">Samples</a>
INA157UA	ACTIVE	SOIC	D	8	75	RoHS & Green	Call TI	Level-3-260C-168 HR		INA 157U A	<a href="#">Samples</a>
INA157UA/2K5	ACTIVE	SOIC	D	8	2500	RoHS & Green	Call TI	Level-3-260C-168 HR		INA 157U A	<a href="#">Samples</a>

(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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "-" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

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**TAPE AND REEL INFORMATION**

**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
INA157U/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
INA157UA/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
INA157U/2K5	SOIC	D	8	2500	356.0	356.0	35.0
INA157UA/2K5	SOIC	D	8	2500	356.0	356.0	35.0

**TUBE**


\*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
INA157U	D	SOIC	8	75	506.6	8	3940	4.32
INA157UA	D	SOIC	8	75	506.6	8	3940	4.32

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