

INA111

High Speed FET-Input INSTRUMENTATION AMPLIFIER

FEATURES

- FET INPUT: $I_B = 20\text{pA max}$
- HIGH SPEED: $T_s = 4\mu\text{s (G = 100, 0.01\%)}$
- LOW OFFSET VOLTAGE: $500\mu\text{V max}$
- LOW OFFSET VOLTAGE DRIFT: $5\mu\text{V/}^\circ\text{C max}$
- HIGH COMMON-MODE REJECTION: 106dB min
- 8-PIN PLASTIC DIP, SOL-16 SOIC

APPLICATIONS

- MEDICAL INSTRUMENTATION
- DATA ACQUISITION

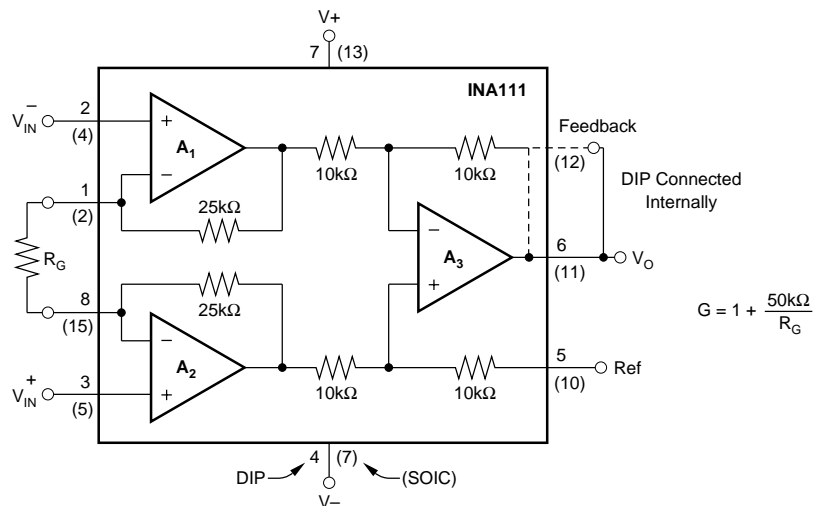
DESCRIPTION

The INA111 is a high speed, FET-input instrumentation amplifier offering excellent performance.

The INA111 uses a current-feedback topology providing extended bandwidth (2MHz at $G = 10$) and fast settling time ($4\mu\text{s}$ to 0.01% at $G = 100$). A single external resistor sets any gain from 1 to over 1000.

Offset voltage and drift are laser trimmed for excellent DC accuracy. The INA111's FET inputs reduce input bias current to under 20pA, simplifying input filtering and limiting circuitry.

The INA111 is available in 8-pin plastic DIP, and SOL-16 surface-mount packages, specified for the -40°C to $+85^\circ\text{C}$ temperature range.



SPECIFICATIONS

ELECTRICAL

At $T_A = +25^\circ\text{C}$, $V_S = \pm 15\text{V}$, $R_L = 2\text{k}\Omega$, unless otherwise noted.

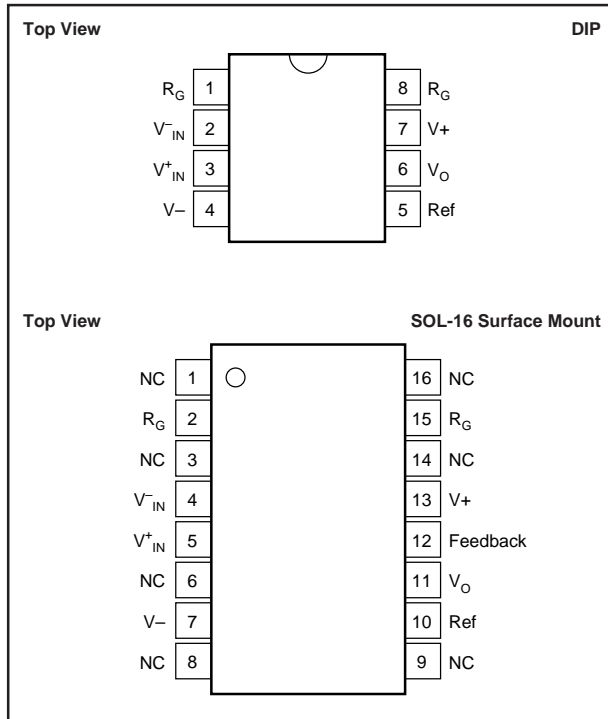
PARAMETER	CONDITIONS	INA111BP, BU			INA111AP, AU			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
INPUT								
Offset Voltage, RTI								
Initial	$T_A = +25^\circ\text{C}$		$\pm 100 \pm 500/\text{G}$	$\pm 500 \pm 2000/\text{G}$		$\pm 200 \pm 500/\text{G}$	$\pm 1000 \pm 5000/\text{G}$	μV
vs Temperature	$T_A = T_{\text{MIN}}$ to T_{MAX}		$\pm 2 \pm 10/\text{G}$	$\pm 5 \pm 100/\text{G}$		$\pm 2 \pm 20/\text{G}$	$\pm 10 \pm 100/\text{G}$	$\mu\text{V}/^\circ\text{C}$
vs Power Supply	$V_S = \pm 6\text{V}$ to $\pm 18\text{V}$		$2 + 10/\text{G}$	$30 + 100/\text{G}$		*	*	$\mu\text{V}/\text{V}$
Impedance, Differential			$10^{12} \parallel 6$			*	*	$\Omega \parallel \text{pF}$
Common-Mode			$10^{12} \parallel 3$			*	*	$\Omega \parallel \text{pF}$
Input Common-Mode Range	$V_{\text{DIFF}} = 0\text{V}$	± 10	± 12		*	*		V
Common-Mode Rejection	$V_{\text{CM}} = \pm 10\text{V}$, $\Delta R_S = 1\text{k}\Omega$							
	G = 1	80	90		75	*		dB
	G = 10	96	110		90	*		dB
	G = 100	106	115		100	*		dB
	G = 1000	106	115		100	*		dB
BIAS CURRENT			± 2	± 20		*	*	pA
OFFSET CURRENT			± 0.1	± 10		*	*	pA
NOISE VOLTAGE, RTI	G = 1000, $R_S = 0\Omega$							
f = 100Hz			13			*		$\text{nV}/\sqrt{\text{Hz}}$
f = 1kHz			10			*		$\text{nV}/\sqrt{\text{Hz}}$
f = 10kHz			10			*		$\text{nV}/\sqrt{\text{Hz}}$
$f_B = 0.1\text{Hz}$ to 10Hz			1			*		$\mu\text{Vp-p}$
Noise Current								
f = 10kHz			0.8			*		$\text{fA}/\sqrt{\text{Hz}}$
GAIN								
Gain Equation			$1 + (50\text{k}\Omega/R_G)$			*		V/V
Range of Gain		1		10000	*		*	V/V
Gain Error	G = 1, $R_L = 10\text{k}\Omega$		± 0.01	± 0.02		*	0.05	%
	G = 10, $R_L = 10\text{k}\Omega$		± 0.1	± 0.5		*	*	%
	G = 100, $R_L = 10\text{k}\Omega$		± 0.15	± 0.5		*	± 0.7	%
	G = 1000, $R_L = 10\text{k}\Omega$		± 0.25	± 1		*	± 2	%
Gain vs Temperature	G = 1		± 1	± 10		*	*	$\text{ppm}/^\circ\text{C}$
50k Ω Resistance ⁽¹⁾			± 25	± 100		*	*	$\text{ppm}/^\circ\text{C}$
Nonlinearity	G = 1		± 0.0005	± 0.005		*	*	% of FSR
	G = 10		± 0.001	± 0.005		*	± 0.01	% of FSR
	G = 100		± 0.001	± 0.005		*	± 0.01	% of FSR
	G = 1000		± 0.005	± 0.02		*	± 0.04	% of FSR
OUTPUT								
Voltage	$I_O = 5\text{mA}$, T_{MIN} to T_{MAX}	± 11	± 12.7		*	*		V
Load Capacitance Stability			1000			*		pF
Short Circuit Current			$+30/-25$			*		mA
FREQUENCY RESPONSE								
Bandwidth, -3dB	G = 1		2			*		MHz
	G = 10		2			*		MHz
	G = 100		450			*		kHz
	G = 1000		50			*		kHz
Slew Rate	$V_O = \pm 10\text{V}$, G = 2 to 100		17			*		V/ μs
Settling Time, 0.01%	G = 1		2			*		μs
	G = 10		2			*		μs
	G = 100		4			*		μs
	G = 1000		30			*		μs
Overload Recovery	50% Overdrive		1			*		μs
POWER SUPPLY								
Voltage Range		± 6	± 15	± 18	*	*	*	V
Current	$V_{\text{IN}} = 0\text{V}$		± 3.3	± 4.5		*	*	mA
TEMPERATURE RANGE								
Specification		-40		85	*		*	$^\circ\text{C}$
Operating		-40		125	*		*	$^\circ\text{C}$
θ_{JA}			100			*		$^\circ\text{C}/\text{W}$

* Specification same as INA111BP.

NOTE: (1) Temperature coefficient of the "50k Ω " term in the gain equation.

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PIN CONFIGURATIONS



ABSOLUTE MAXIMUM RATINGS⁽¹⁾

Supply Voltage	±18V
Input Voltage Range	(V ₋) -0.7V to (V ₊) +15V
Output Short-Circuit (to ground)	Continuous
Operating Temperature	-40°C to +125°C
Storage Temperature	-40°C to +125°C
Junction Temperature	+150°C
Lead Temperature (soldering, 10s)	+300°C

NOTE: Stresses above these ratings may cause permanent damage.

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.

ORDERING INFORMATION

PRODUCT	PACKAGE	TEMPERATURE RANGE
INA111AP	8-Pin Plastic DIP	-40°C to +85°C
INA111BP	8-Pin Plastic DIP	-40°C to +85°C
INA111AU	SOL-16 Surface-Mount	-40°C to +85°C
INA111BU	SOL-16 Surface-Mount	-40°C to +85°C

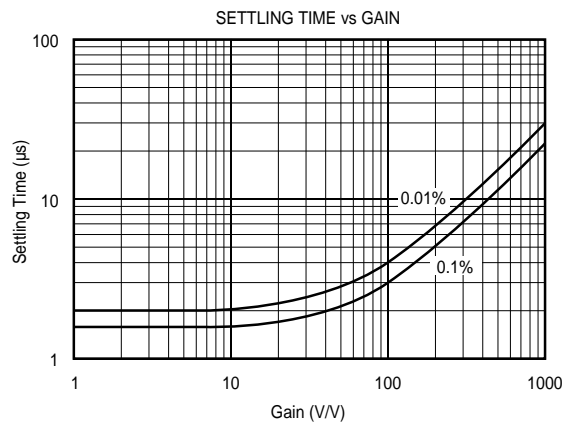
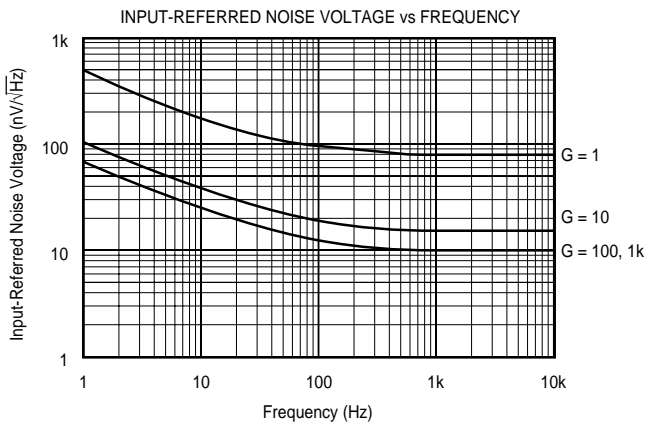
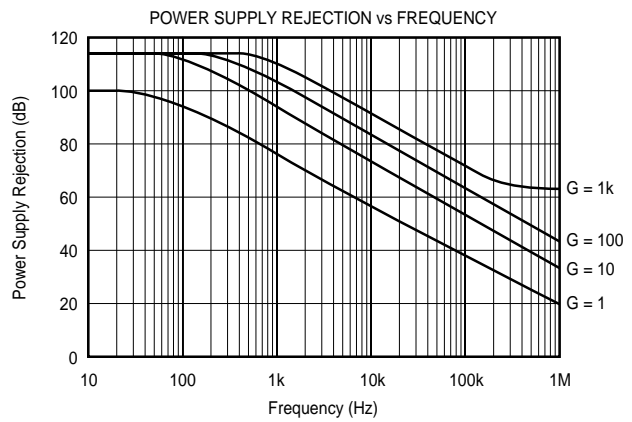
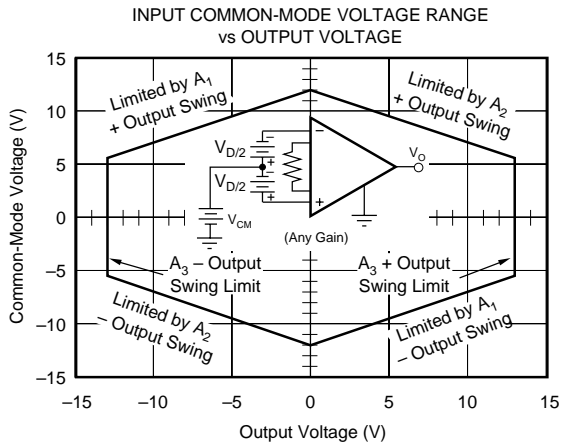
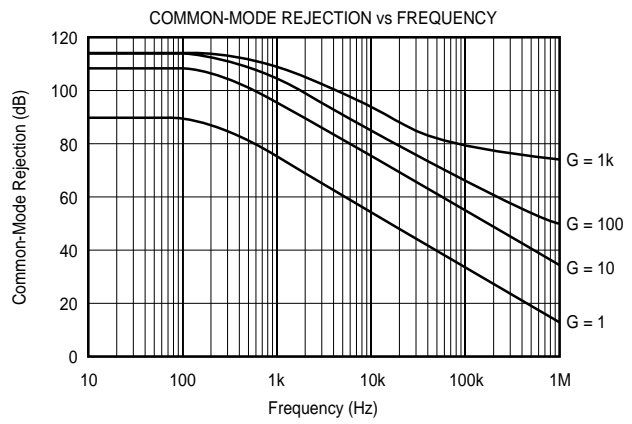
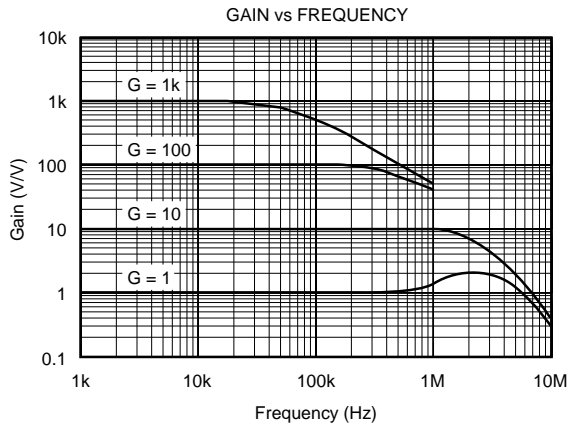
PACKAGE INFORMATION

PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER ⁽¹⁾
INA111AP	8-Pin Plastic DIP	006
INA111BP	8-Pin Plastic DIP	006
INA111AU	16-Pin Surface Mount	211
INA111BU	16-Pin Surface Mount	211

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book.

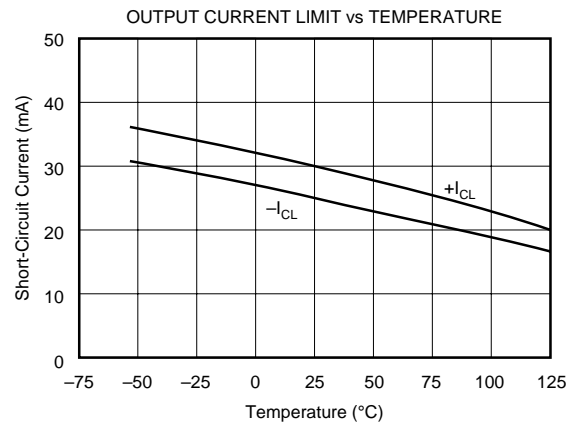
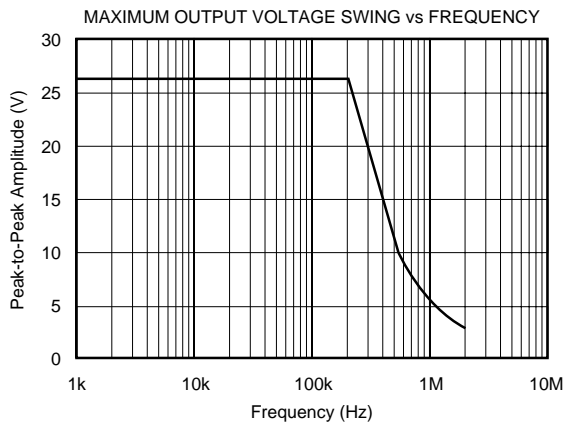
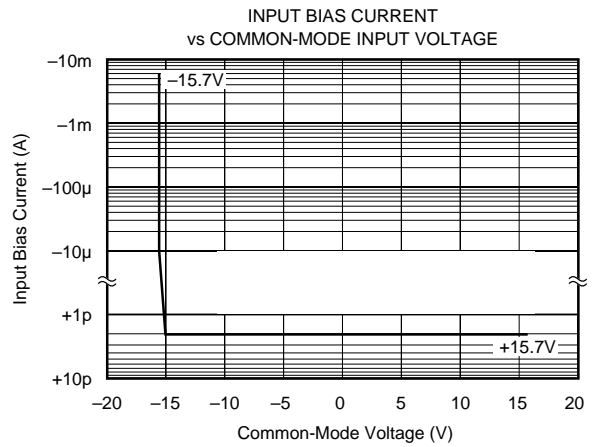
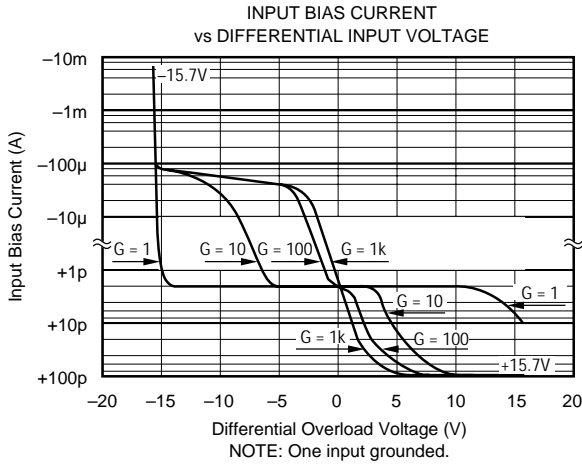
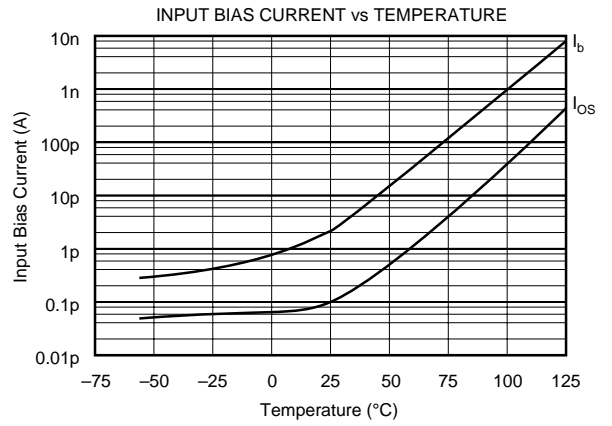
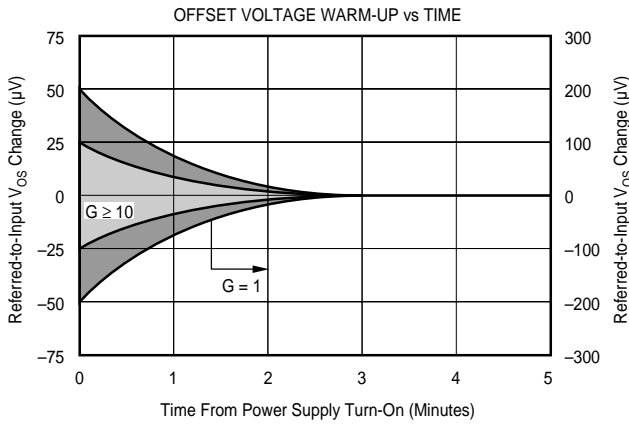
TYPICAL PERFORMANCE CURVES

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



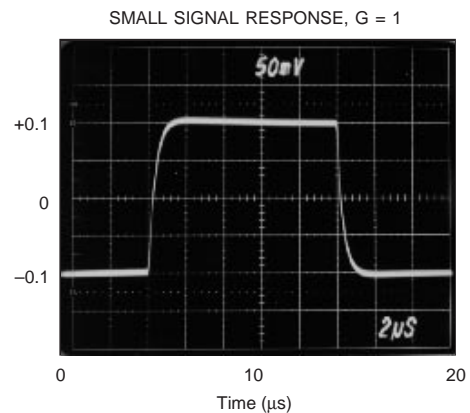
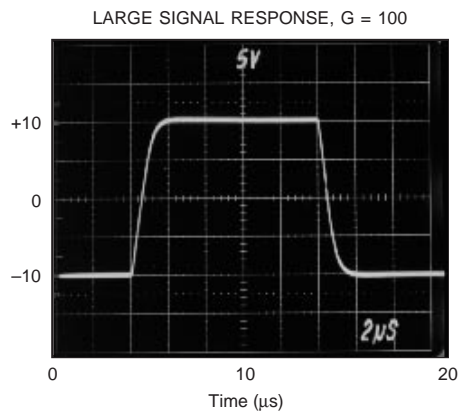
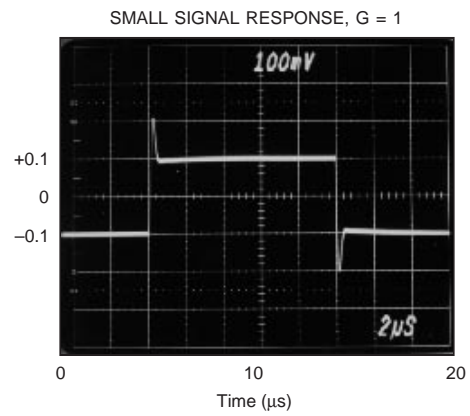
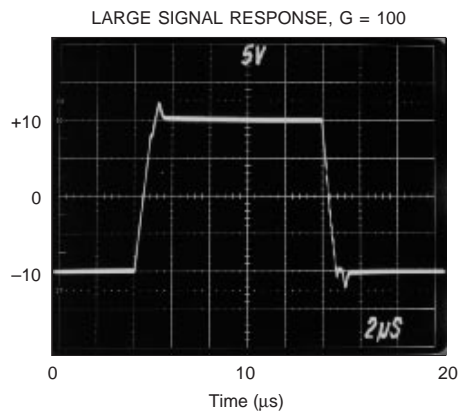
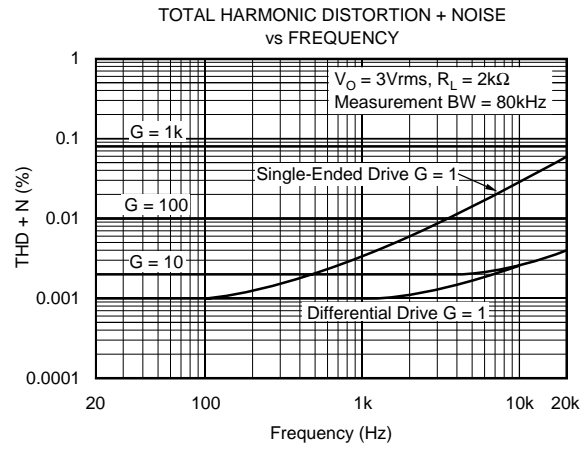
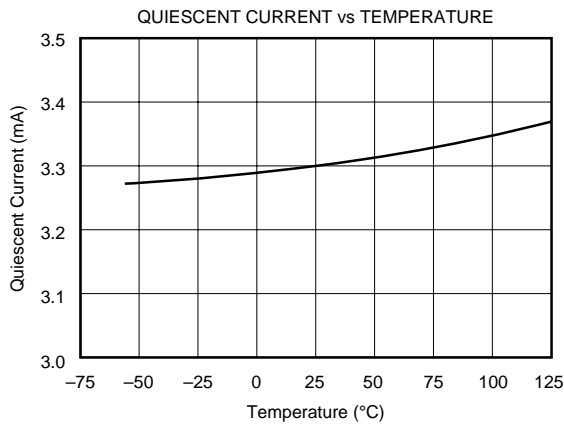
TYPICAL PERFORMANCE CURVES (CONT)

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



TYPICAL PERFORMANCE CURVES (CONT)

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



APPLICATION INFORMATION

Figure 1 shows the basic connections required for operation of the INA111. Applications with noisy or high impedance power supplies may require decoupling capacitors close to the device pins as shown.

The output is referred to the output reference (Ref) terminal which is normally grounded. This must be a low-impedance connection to assure good common-mode rejection. A resistance of 2Ω in series with the Ref pin will cause a typical device with 90dB CMR to degrade to approximately 80dB CMR ($G = 1$).

SETTING THE GAIN

Gain of the INA111 is set by connecting a single external resistor, R_G :

$$G = 1 + \frac{50k\Omega}{R_G} \quad (1)$$

Commonly used gains and resistor values are shown in Figure 1.

The 50kΩ term in equation 1 comes from the sum of the two internal feedback resistors. These are on-chip metal film resistors which are laser trimmed to accurate absolute values. The accuracy and temperature coefficient of these resistors are included in the gain accuracy and drift specifications of the INA111.

The stability and temperature drift of the external gain setting resistor, R_G , also affects gain. R_G 's contribution to gain accuracy and drift can be directly inferred from the gain equation (1). Low resistor values required for high gain can make wiring resistance important. Sockets add to the wiring resistance, which will contribute additional gain error (possibly an unstable gain error) in gains of approximately 100 or greater.

DYNAMIC PERFORMANCE

The typical performance curve "Gain vs Frequency" shows that the INA111 achieves wide bandwidth over a wide range of gain. This is due to the current-feedback topology of the INA111. Settling time also remains excellent over wide gains.

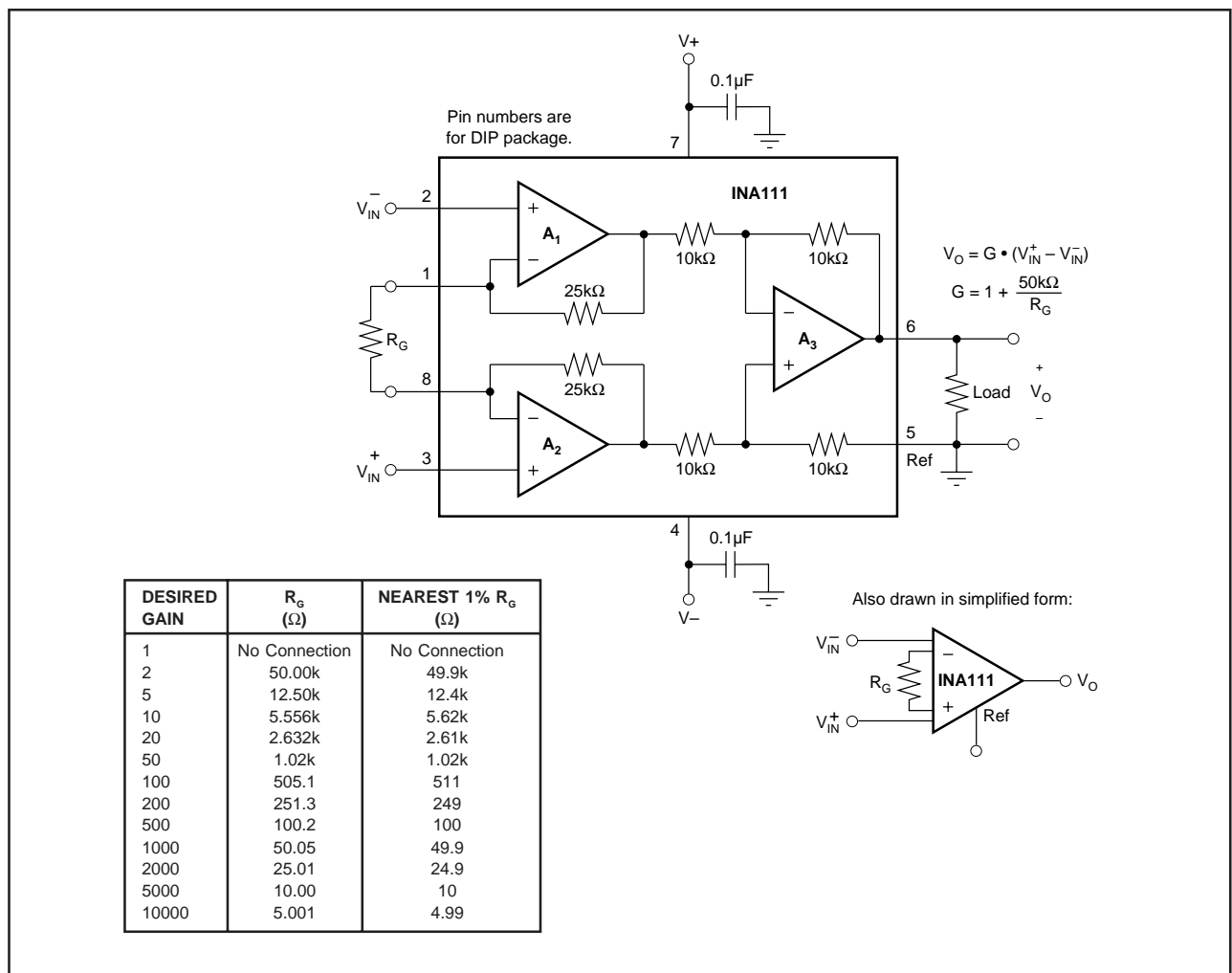


FIGURE 1. Basic Connections

A combination of common-mode and differential input voltage can cause the output of A_1 or A_2 to saturate. Figure 4 shows the output voltage swing of A_1 and A_2 expressed in terms of a common-mode and differential input voltages. For applications where input common-mode range must be maximized, limit the output voltage swing by connecting the INA111 in a lower gain (see performance curve "Input Common-Mode Voltage Range vs Output Voltage"). If necessary, add gain after the INA111 to increase the voltage swing.

Input-overload often produces an output voltage that appears normal. For example, consider an input voltage of +14V on one input and +15V on the other input will obviously exceed the linear common-mode range of both input amplifiers. Since both input amplifiers are saturated to the nearly the same output voltage limit, the difference voltage measured by the output amplifier will be near zero. The output of the INA111 will be near 0V even though both inputs are overloaded.

INPUT PROTECTION

Inputs of the INA111 are protected for input voltages from 0.7V below the negative supply to 15V above the positive power supply voltages. If the input current is limited to less than 1mA, clamp diodes are not required; internal junctions will clamp the input voltage to safe levels. If the input source can supply more than 1mA, use external clamp diodes as shown in Figure 5. The source current can be limited with series resistors R_1 and R_2 as shown. Resistor values greater than 10k Ω will contribute noise to the circuit.

A diode formed with a 2N4117A transistor as shown in Figure 5 assures low leakage. Common signal diodes such as

the 1N4148 may have leakage currents far greater than the input bias current of the INA111 and are usually sensitive to light.

INPUT FILTERING

The INA111's FET input allows use of an R/C input filter without creating large offsets due to input bias current. Figure 6 shows proper implementation of this input filter to preserve the INA111's excellent high frequency common-mode rejection. Mismatch of the common-mode input capacitance (C_1 and C_2), either from stray capacitance or

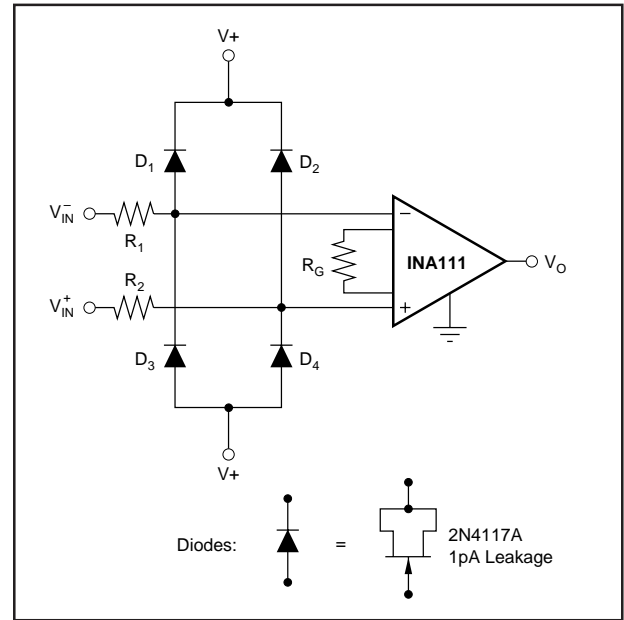


FIGURE 5. Input Protection Voltage Clamp.

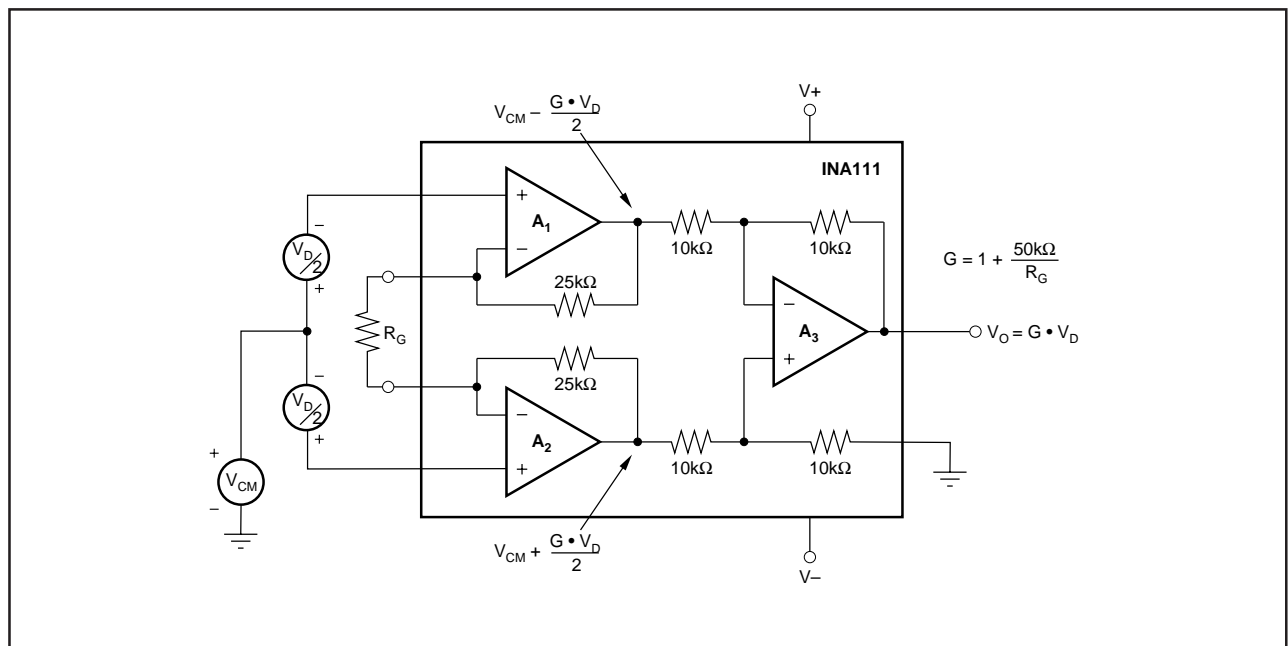


FIGURE 4. Voltage Swing of A_1 and A_2 .

mismatched values, causes a high frequency common-mode signal to be converted to a differential signal. This degrades common-mode rejection. The differential input capacitor, C_3 , reduces the bandwidth and mitigates the effects of mismatch in C_1 and C_2 . Make C_3 much larger than C_1 and C_2 . If properly matched, C_1 and C_2 also improve CMR.

OUTPUT VOLTAGE SENSE (SOL-16 Package Only)

The surface-mount version of the INA111 has a separate output sense feedback connection (pin 12). Pin 12 must be connected, usually to the output terminal, pin 11, for proper operation. (This connection is made internally on the DIP version of the INA111.)

The output feedback connection can be used to sense the output voltage directly at the load for best accuracy. Figure 8 shows how to drive a load through series interconnection resistance. Remotely located feedback paths may cause instability. This can be generally be eliminated with a high frequency feedback path through C_1 .

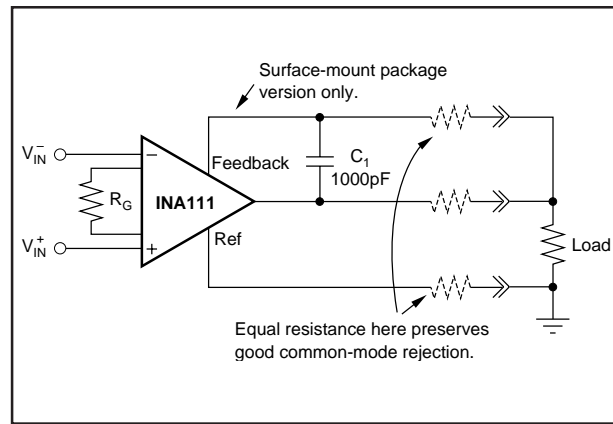


FIGURE 8. Remote Load and Ground Sensing.

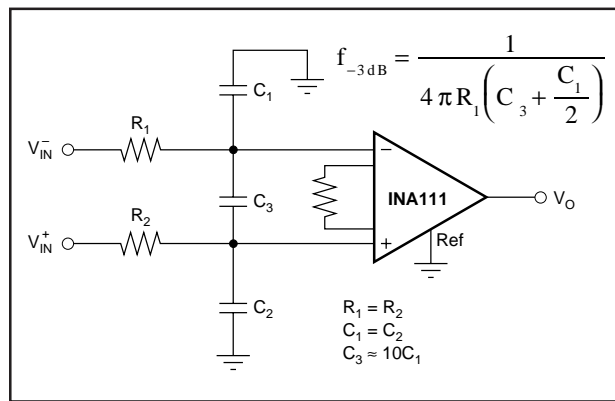
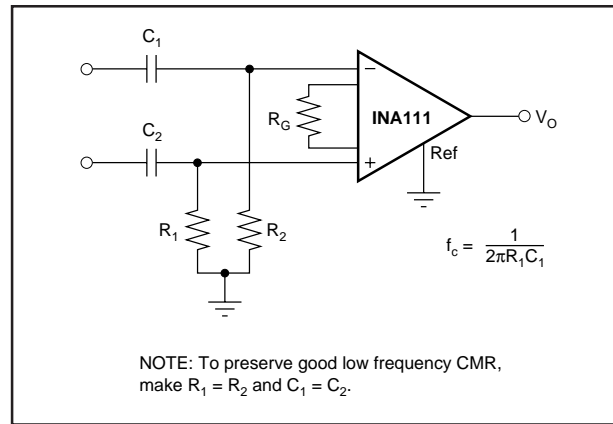


FIGURE 6. Input Low-Pass Filter.



NOTE: To preserve good low frequency CMR, make $R_1 = R_2$ and $C_1 = C_2$.

FIGURE 9. High-Pass Input Filter.

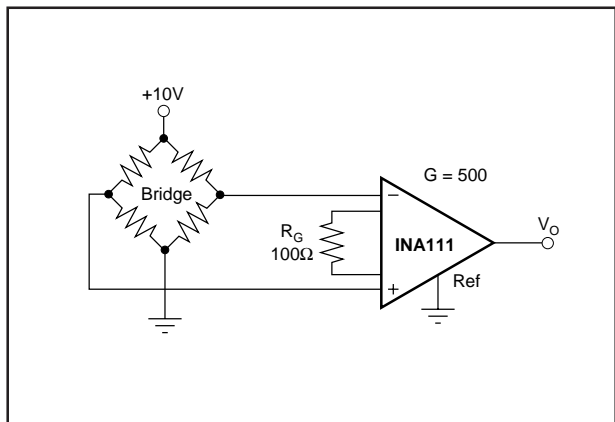


FIGURE 7. Bridge Transducer Amplifier.

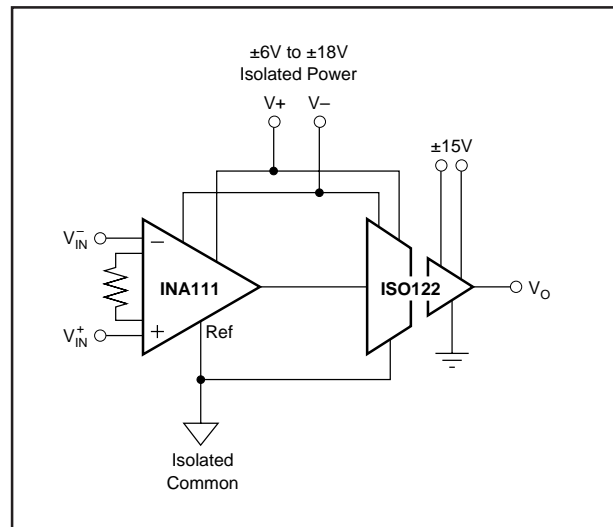


FIGURE 10. Galvanically Isolated Instrumentation Amplifier.

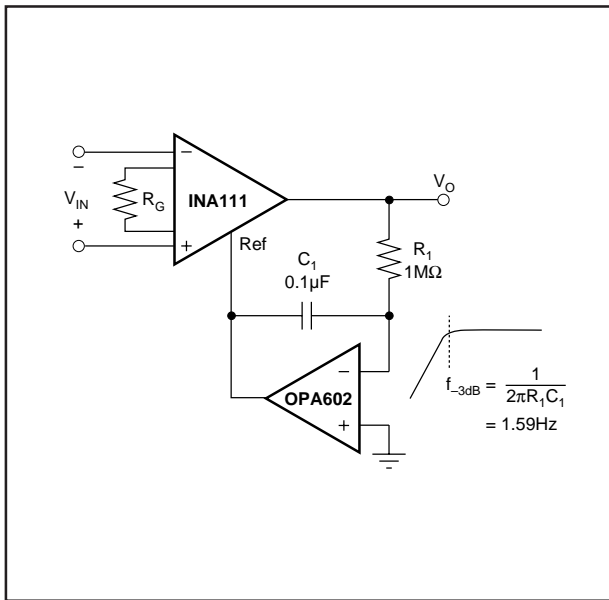


FIGURE 11. AC-Coupled Instrumentation Amplifier.

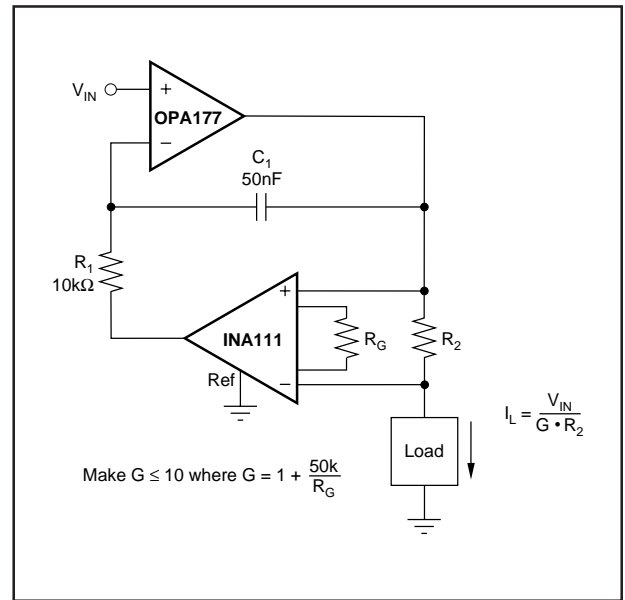


FIGURE 12. Voltage Controlled Current Source.

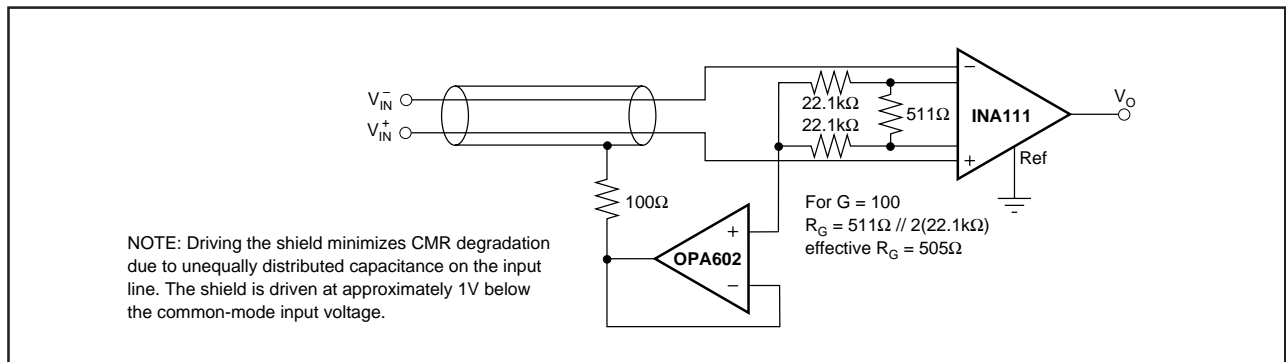


FIGURE 13. Shield Driver Circuit.

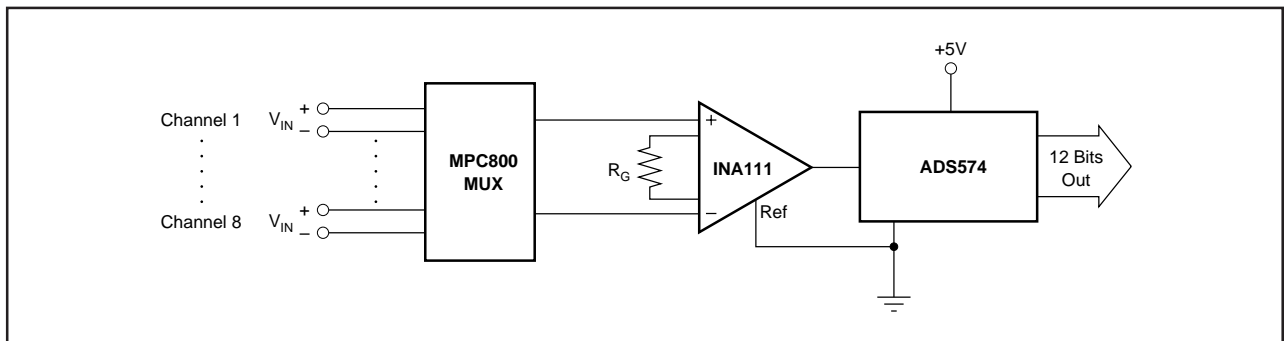


FIGURE 14. Multiplexed-Input Data Acquisition System.

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)
INA111AP	Active	Production	PDIP (P) 8	50 TUBE	Yes	NIPDAU	N/A for Pkg Type	-	INA111AP
INA111AU	Active	Production	SOIC (DW) 16	40 TUBE	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	INA111AU
INA111AU/1K	Active	Production	SOIC (DW) 16	1000 LARGE T&R	Yes	Call TI	Level-3-260C-168 HR	-40 to 85	INA111AU
INA111BP	Active	Production	PDIP (P) 8	50 TUBE	Yes	NIPDAU	N/A for Pkg Type	-	INA111BP
INA111BU	Active	Production	SOIC (DW) 16	40 TUBE	Yes	NIPDAU	Level-3-260C-168 HR	-	INA111BU

⁽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.

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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
INA111AU/1K	SOIC	DW	16	1000	330.0	16.4	10.75	10.7	2.7	12.0	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)
INA111AU/1K	SOIC	DW	16	1000	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)
INA111AP	P	PDIP	8	50	506	13.97	11230	4.32
INA111AU	DW	SOIC	16	40	507	12.83	5080	6.6
INA111BP	P	PDIP	8	50	506	13.97	11230	4.32
INA111BU	DW	SOIC	16	40	507	12.83	5080	6.6

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