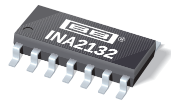
BURR - BROWN®



INA2132

Dual, Low Power, Single-Supply DIFFERENCE AMPLIFIER

FEATURES

- DESIGNED FOR LOW COST
- LOW QUIESCENT CURRENT: 160µA per Amplifier
- WIDE POWER SUPPLY RANGE: Single Supply: 2.7V to 36V Dual Supplies: ±1.35V to ±18V
- LOW GAIN ERROR: ±0.05% max
- LOW NONLINEARITY: 0.001% max
- HIGH CMRR: 90dB
- HIGHLY VERSATILE CIRCUIT
- EASY TO USE
- SO-14 PACKAGE

APPLICATIONS

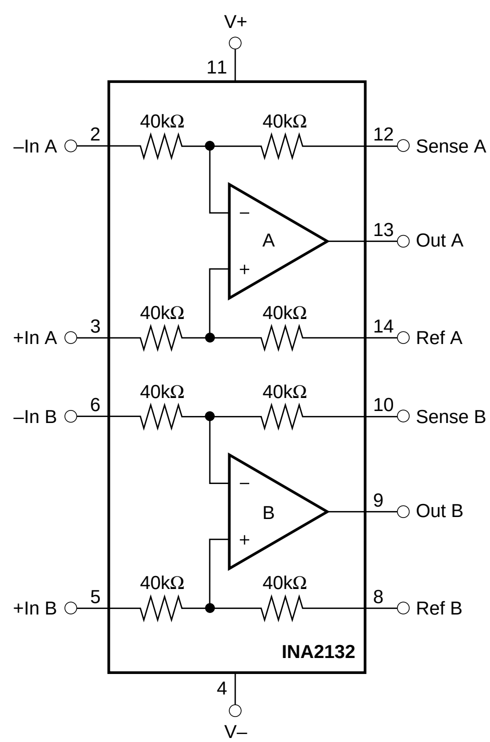
- DIFFERENTIAL INPUT AMPLIFIER
- INSTRUMENTATION AMPLIFIER BUILDING BLOCK
- UNITY-GAIN INVERTING AMPLIFIER
- G = 1/2 AMPLIFIER
- G = 2 AMPLIFIER
- SUMMING AMPLIFIER
- DIFFERENTIAL CURRENT RECEIVER
- VOLTAGE-CONTROLLED CURRENT SOURCE
- BATTERY-POWERED SYSTEMS
- GROUND LOOP ELIMINATOR

DESCRIPTION

The INA2132 is a dual low power, unity-gain difference amplifier offering excellent value at very low cost. Each channel consists of a precision op amp with a laser-trimmed precision resistor network, providing accurate gain and high common-mode rejection. Excellent TCR tracking of the resistors maintains gain accuracy and common-mode rejection over temperature. The internal op amp's common-mode range extends to the negative supply—ideal for single-supply applications.

The difference amplifier is the foundation of many commonly used circuits. The INA2132 provides this circuit function without using an expensive precision resistor network. The INA2132 is available in the SO-14 surface-mount package and is specified for operation over the extended industrial temperature range, –40°C to +85°C.

A single version of this product with similar specifications is also available. See the INA132 data sheet for details.



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Twx: 910-952-1111 • Internet: http://www.burr-brown.com/ • Cable: BBRCORP • Telex: 066-6491 • FAX: (520) 889-1510 • Immediate Product Info: (800) 548-6132

PDS-1488A

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SBOS108

SPECIFICATIONS: $V_S = \pm15V$

At T_A = +25°C, R_L = 10kΩ connected to ground, and reference pins connected to ground unless otherwise noted.

PARAMETER	CONDITIONS	INA2132U			INA2132UA			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
OFFSET VOLTAGE(1)	RTO							
Initial V_{OS}			±75	±250		*	±500	μV
vs Temperature dV_{OS}/dT			±1	±5		*	±10	μV/°C
vs Power Supply PSRR	V_S = ±1.35V to ±18V		±5	±30		*	*	μV/V
vs Time			0.3			*		μV/mo
Channel Separation(2)	dc		0.04					μV/V
INPUT IMPEDANCE(3)								
Differential			80			*		kΩ
Common-Mode			40			*		kΩ
INPUT VOLTAGE RANGE								
Common-Mode Voltage Range(4)	V_O = 0V	2 (V–)		2 (V+) –2	*		*	V
Common-Mode Rejection Ratio CMRR	V_{CM} = –30V to 28V, R_S = 0Ω	80	90		74	*		dB
OUTPUT VOLTAGE NOISE(5)	RTO							
f = 0.1Hz to 10Hz			1.6			*		μVp-p
f = 1kHz			65			*		nV/√Hz
GAIN								
Initial			1			*		V/V
Error	V_O = –14V to 13.5V		±0.01	±0.05		*	±0.1	%
vs Temperature			±1	±10		*	*	ppm/°C
Nonlinearity	V_O = –14V to 13.5V		±0.0001	±0.001		*	±0.002	% of FS
OUTPUT								
Voltage, Positive	R_L = 100kΩ to Ground	(V+) –1	(V+) –0.8		*	*		V
Negative	R_L = 100kΩ to Ground	(V–) +0.5	(V–) +0.15		*	*		V
Positive	R_L = 10kΩ to Ground	(V+) –1.5	(V+) –0.8		*	*		V
Negative	R_L = 10kΩ to Ground	(V–) +1	(V–) +0.25		*	*		V
Current Limit, per Amplifier	Continuous to Common		±12			*		mA
Capacitive Load (stable operation)			10			*		nF
FREQUENCY RESPONSE								
Small-Signal Bandwidth	–3dB		300			*		kHz
Slew Rate SR			0.1			*		V/μs
Settling Time: 0.1%	V_O = 10V Step		85			*		μs
0.01%	V_O = 10V Step		88			*		μs
Overload Recovery Time	50% Overdrive		7			*		μs
POWER SUPPLY								
Rated Voltage V_S			±15			*		V
Voltage Range		±1.35		±18	*		*	V
Quiescent Current (per amplifier) I_Q	I_O = 0mA		±160	±185		*	*	μA
TEMPERATURE RANGE								
Specification		–40		+85	*		*	°C
Operation		–55		+125	*		*	°C
Storage		–55		+125	*		*	°C
Thermal Resistance θ_{JA}			100			*		°C/W

* Specifications the same as INA2132U.

NOTES: (1) Includes effects of amplifier's input bias and offset currents. (2) Measured output offset change of one channel for a full-scale swing (V_O = –14V to 13.5V) on the opposite channel. (3) 40kΩ resistors are ratio matched but have ±20% absolute value. (4) 2 (V–) $-V_{REF} < V_{CM} <$ 2 ((V+) –1) $-V_{REF}$. For more detail, see Applications Information section. (5) Includes effects of amplifier's input current noise and thermal noise contribution of resistor network.

SPECIFICATIONS: V_S = +5V Single Supply

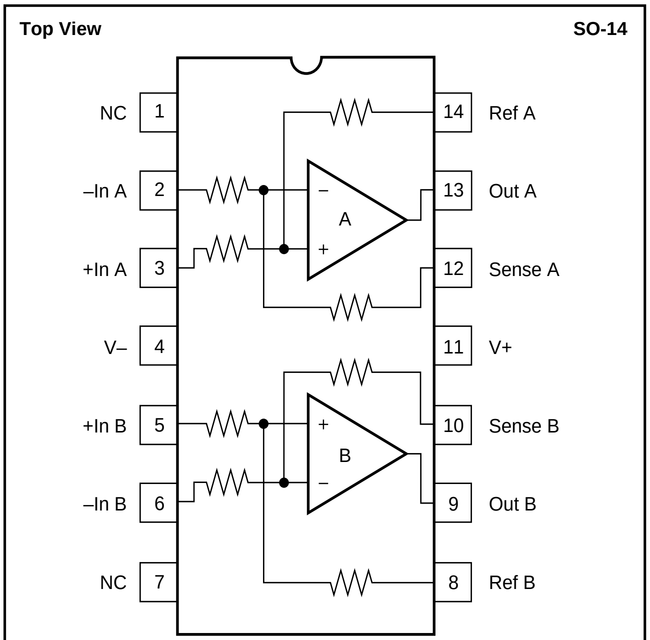
At T_A = +25°C, R_L = 10kΩ connected to $V_S/2$, and reference pin connected to $V_S/2$, unless otherwise noted.

PARAMETER		CONDITIONS	INA2132U MIN	INA2132U TYP	INA2132U MAX	INA2132UA MIN	INA2132UA TYP	INA2132UA MAX	UNITS
OFFSET VOLTAGE(1)		RTO							
Initial	V_{OS}			±150	±500		*	±750	µV
vs Temperature	dV_{OS}/dT			±2			*		µV/°C
INPUT VOLTAGE RANGE									
Common-Mode Voltage Range(2)			–2.5		+5.5	*		*	V
Common-Mode Rejection	CMRR	V_{CM} = –2.5V to +5.5V, R_S = 0Ω	80	90		74	*		dB
OUTPUT									
Voltage, Positive		R_L = 100kΩ to Ground	(V+) –1	(V+) –0.75		*	*		V
Negative		R_L = 100kΩ to Ground	+0.25	+0.06		*	*		V
Positive		R_L = 10kΩ to Ground	(V+) –1	(V+) –0.8		*	*		V
Negative		R_L = 10kΩ to Ground	+0.25	+0.12		*	*		V
POWER SUPPLY									
Rated Voltage	V_S			+5			*		V
Voltage Range			+2.7		+36	*		*	V
Quiescent Current	I_Q	I_O = 0mA		±155	±185		*	*	µA

* Specifications the same as INA2132U.

NOTE: (1) Includes effects of amplifier's input bias and offset currents. (2) 2 (V–) $-V_{REF} < V_{CM} <$ 2 ((V+) –1) $-V_{REF}$. For more detail, see Applications Information section.

PIN CONFIGURATION



NC = No Connection

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V+ to V–	36V
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

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

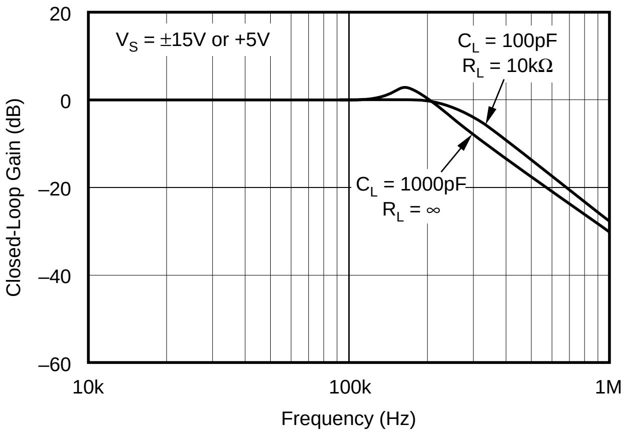
PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER(1)	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER(2)	TRANSPORT MEDIA
INA2132U	SO-14 Surface-Mount	235	–40°C to +85°C	INA2132U	INA2132U	Rails
"	"	"	"	"	INA2132U/2K5	Tape and Reel
INA2132UA	SO-14 Surface-Mount	235	–40°C to +85°C	INA2132UA	INA2132UA	Rails
"	"	"	"	"	INA2132UA/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 "INA2132U/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.

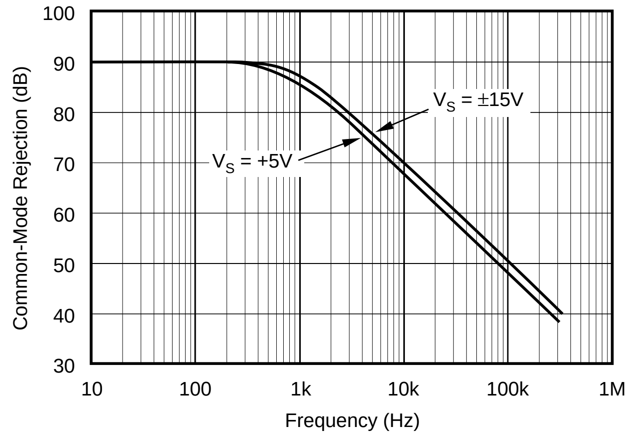
TYPICAL PERFORMANCE CURVES

At T_A = +25°C and V_S = ±15V, unless otherwise noted.

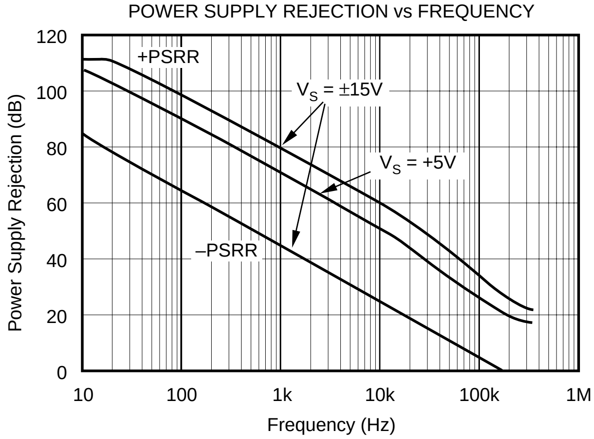
GAIN vs FREQUENCY



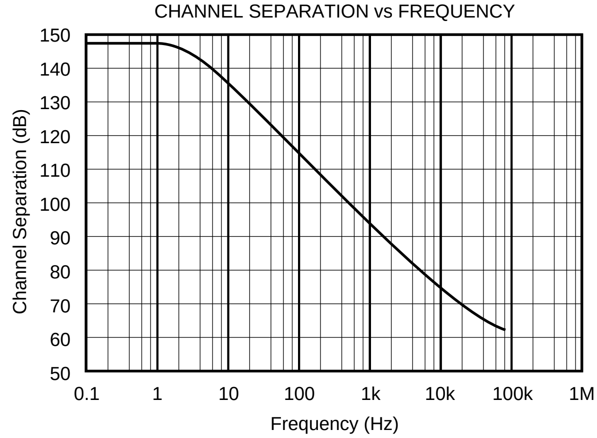
COMMON-MODE REJECTION vs FREQUENCY



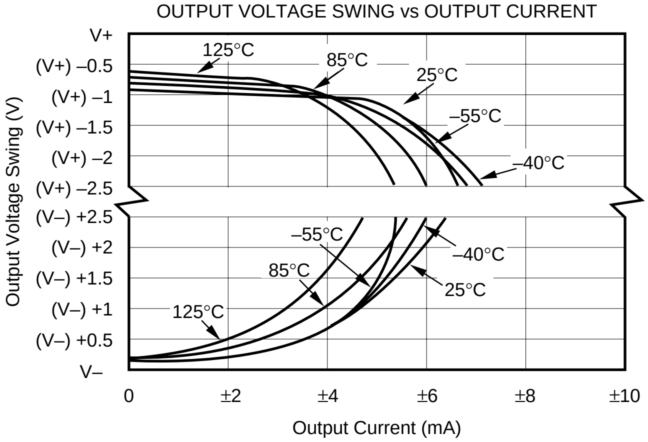
POWER SUPPLY REJECTION vs FREQUENCY



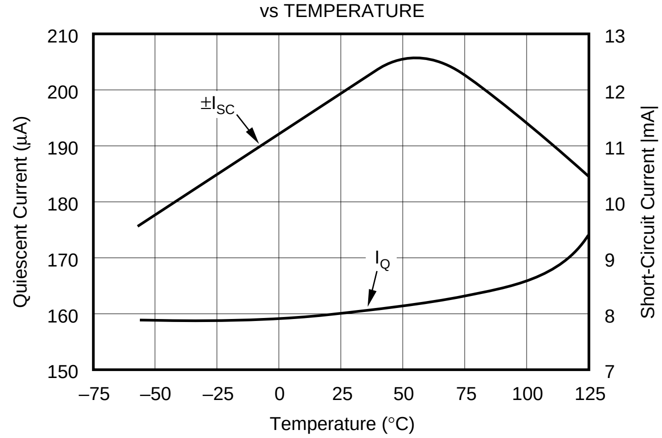
CHANNEL SEPARATION vs FREQUENCY



OUTPUT VOLTAGE SWING vs OUTPUT CURRENT

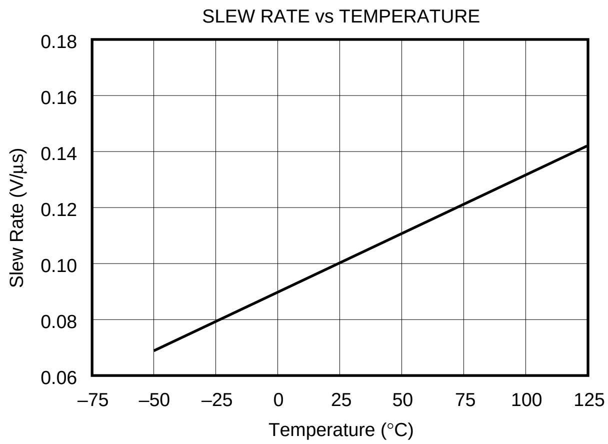


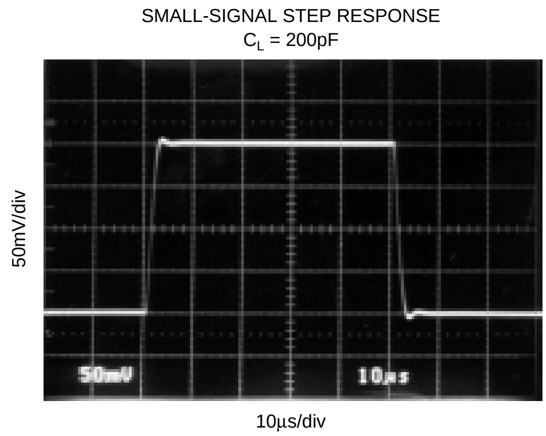
QUIESCENT and SHORT-CIRCUIT CURRENT
vs TEMPERATURE

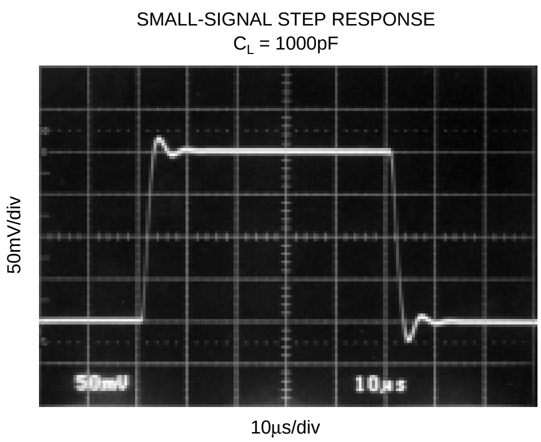


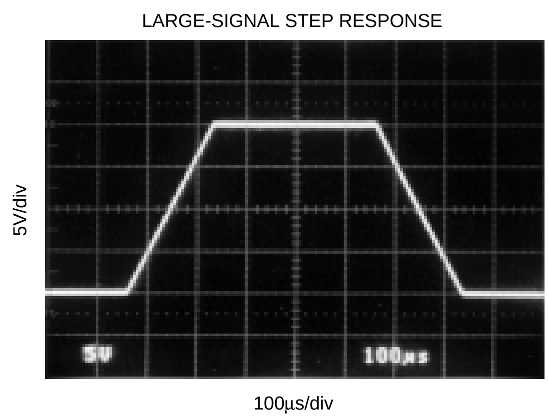
TYPICAL PERFORMANCE CURVES (CONT)

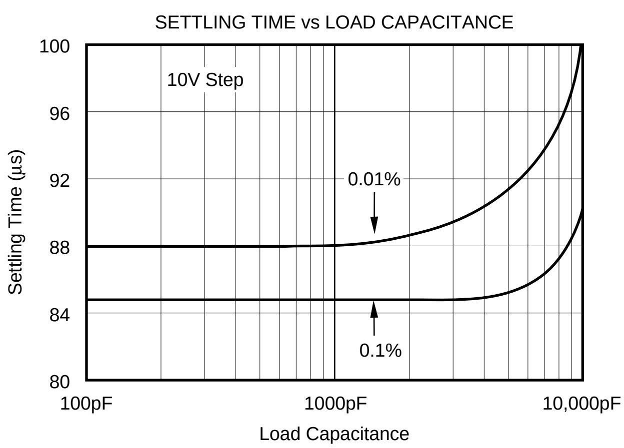
At T_A = +25°C and V_S = ±15V, unless otherwise noted.

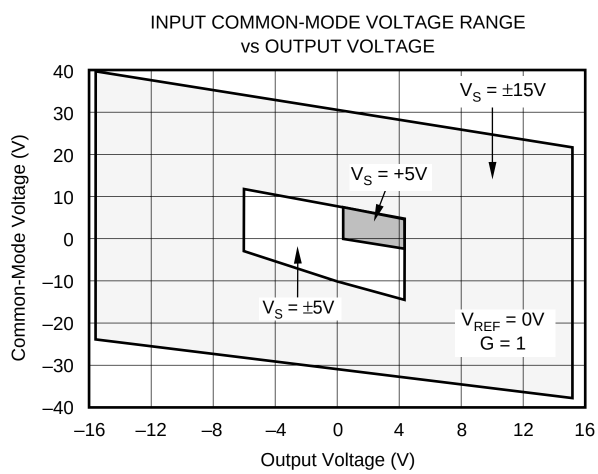






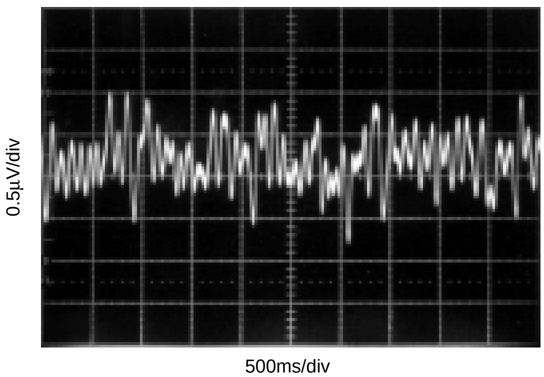




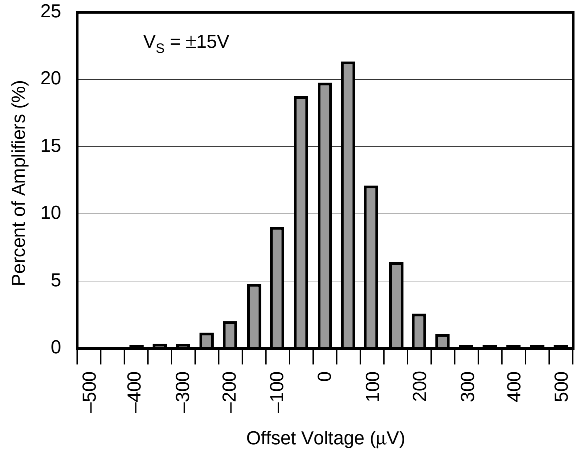


At T_A = +25°C and V_S = ±15V, unless otherwise noted.

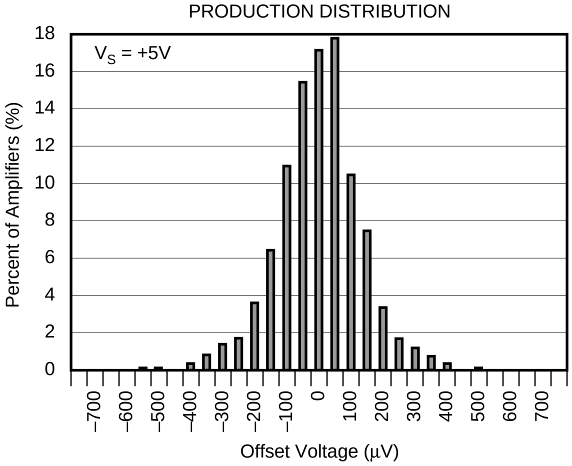
0.1Hz to 10Hz PEAK-TO-PEAK VOLTAGE NOISE



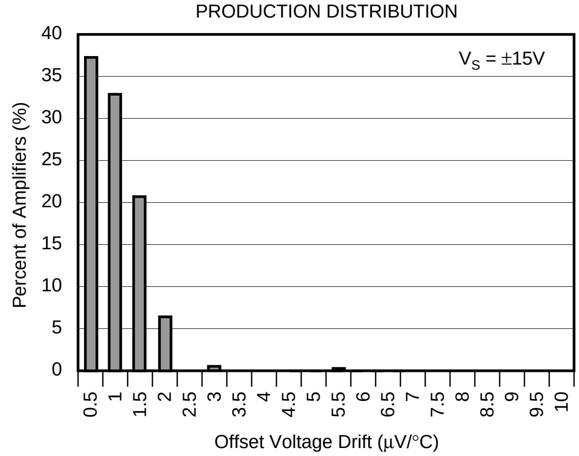
OFFSET VOLTAGE PRODUCTION DISTRIBUTION



OFFSET VOLTAGE PRODUCTION DISTRIBUTION



OFFSET VOLTAGE DRIFT PRODUCTION DISTRIBUTION



APPLICATIONS INFORMATION

Figure 1 shows the basic connections required for operation of the INA2132. Power supply bypass capacitors should be connected close to the device pins.

The differential input signal is connected to pins 2 and 3 (or pins 6 and 5) as shown. The source impedances connected to the inputs must be nearly equal to assure good common-mode rejection. An 8Ω mismatch in source impedance will degrade the common-mode rejection of a typical device to approximately 80dB. Gain accuracy will also be slightly affected. If the source has a known impedance mismatch, an additional resistor in series with one input can be used to preserve good common-mode rejection.

Do not interchange pins 3 and 14 (or pins 5 and 8) or pins 2 and 12 (or pins 6 and 10), even though nominal resistor values are equal. These resistors are laser-trimmed for precise resistor ratios to achieve accurate gain and highest CMRR. Interchanging these pins may not provide specified performance. As shown in Figure 1, sense line should be connected as close to the load as possible.

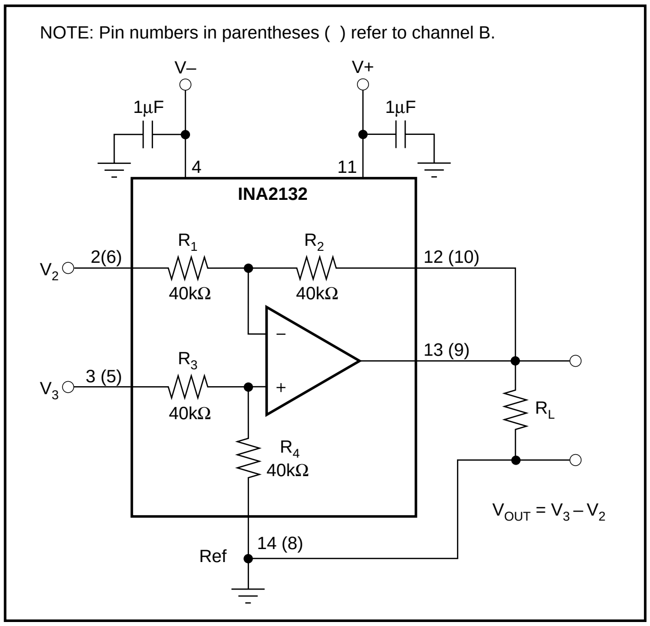


FIGURE 1. Basic Power Supply and Signal Connections.

To ensure valid operation of the differential amplifier, please note the following points:

1) $V_{OUT} = V_3 - V_2 + V_{REF}$
2) V_{OUT} must be within the specified linear range. For example, with ±15V supplies and a 100kΩ load, the output will be defined by:

$$(V-) + 0.15V < V_{OUT} < (V+) - 0.8V$$

3) Input common-mode range at the nodes of the op amp must be $V- \leq V_{CM} \leq (V+) - 1$. To ensure that the inputs to the differential amp (+In and –In) meet this criteria, limit the common-mode voltage inputs to:

$$2 \bullet (V-) - V_{REF} < V_{CM} < 2 \bullet ((V+) - 1) - V_{REF}$$

In the case where V_{REF} is grounded, the equation simplifies to:

$$2 \bullet (V-) < V_{CM} < 2 \bullet ((V+) - 1)$$

For more information, see the typical performance curve titled “Input Common-Mode Voltage Range vs Output Voltage.”

OPERATING VOLTAGE

The INA2132 operates from single (+2.7V to +36V) or dual (±1.35V to ±18V) supplies with excellent performance. Specifications are production tested with +5V and ±15V supplies. Most behavior remains unchanged throughout the full operating voltage range. Parameters which vary significantly with operating voltage are shown in the Typical Performance Curves.

The INA2132 can accurately measure differential signals that are beyond the power supply rails. Linear common-mode range extends to twice the negative power supply voltage and nearly twice the positive power supply voltage. Output phase reversal does not occur when the inputs to the internal operational amplifier are overloaded to either rail. See typical performance curve, “Common-Mode Range vs Output Voltage.”

OFFSET VOLTAGE TRIM

The INA2132 is laser-trimmed for low offset voltage and drift. Most applications require no external offset adjustment. Figure 2 shows an optional circuit for trimming the output offset voltage. The output is referred to the output reference terminal (pin 14 or pin 8), 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. The source impedance of a signal applied to the Ref terminal should be less than 8Ω to maintain good common-mode rejection. To assure low impedance at the Ref terminal, the trim voltage can be buffered with an op amp, such as the OPA277.

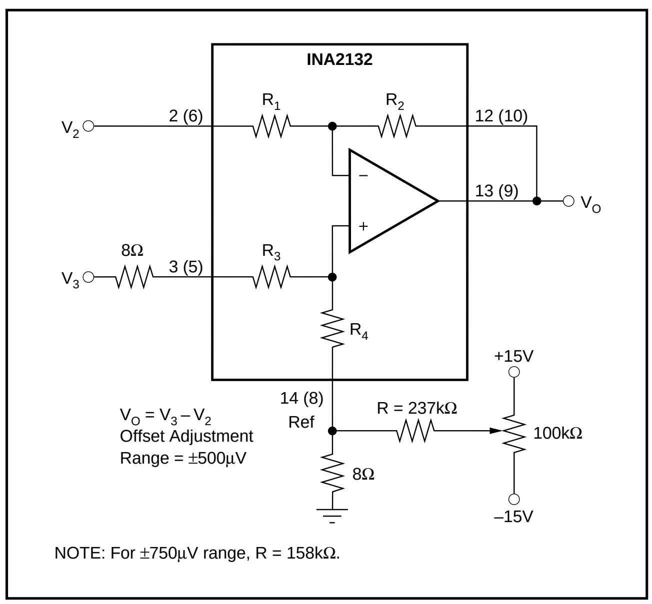


FIGURE 2. Offset Adjustment.

CAPACITIVE LOAD DRIVE CAPABILITY

The INA2132 can drive large capacitive loads, even at low supplies. It is stable with a 10nF load. Refer to the "Small-Signal Step Response" and "Settling Time vs Load Capacitance" typical performance curves.

CHANNEL CROSSTALK

The two channels of the INA2132 are completely independent, including all bias circuitry. At dc and low frequency, there is virtually no signal coupling between channels. Crosstalk increases with frequency and is dependent on source impedance and signal characteristics. See the typical performance curve "Channel Separation vs Frequency" for more information.

Most crosstalk is produced by capacitive coupling of signals from one channel to the input section of the other channel. To minimize coupling, separate the input traces as far as practical from any signals associated with the opposite channel. A grounded guard trace surrounding the inputs helps reduce stray coupling between channels. Run the differential inputs of each channel parallel to each other or directly adjacent on the top and bottom sides of a circuit board. Stray coupling then produces a common-mode signal which is rejected by the INA2132's input.

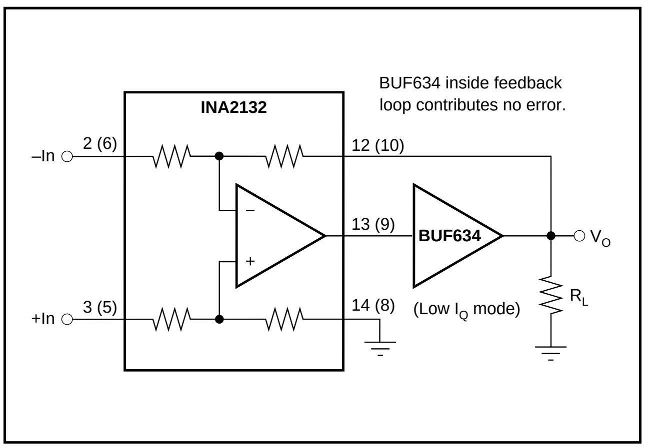


FIGURE 3. Low Power, High Output Current Precision Difference Amplifier.

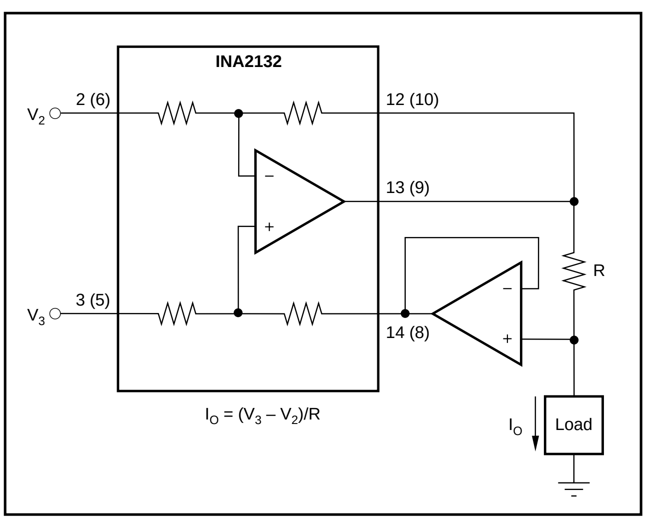


FIGURE 4. Differential Input Voltage-to-Current Converter for Low I_{OUT}.

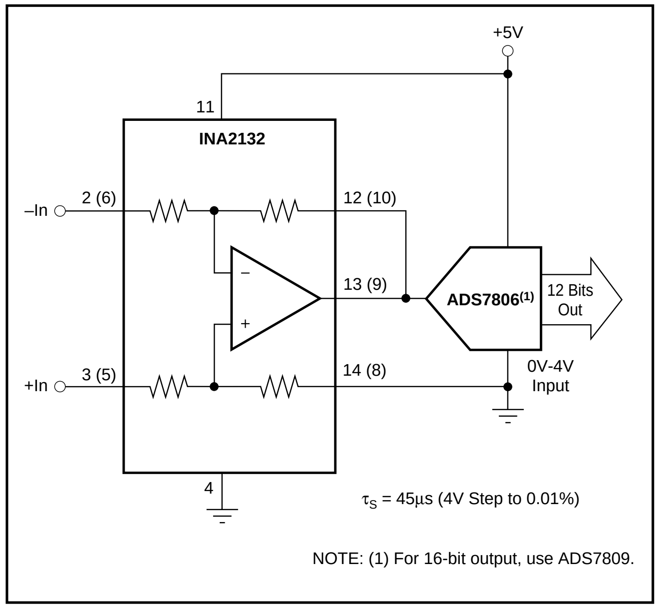


FIGURE 5. Differential Input Data Acquisition.

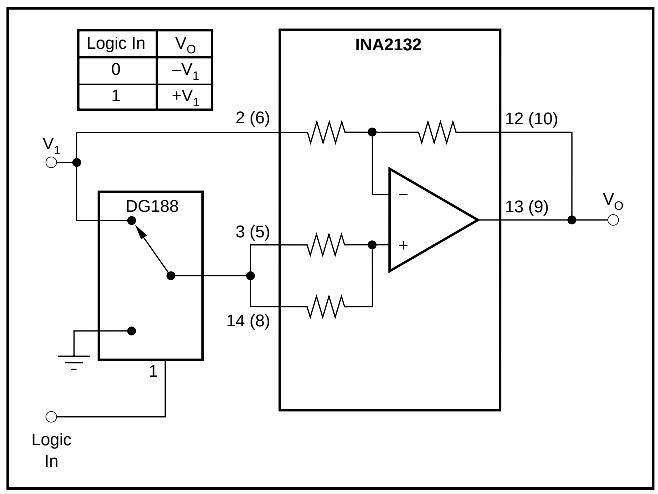


FIGURE 6. Digitally Controlled Gain of ±1 Amplifier.

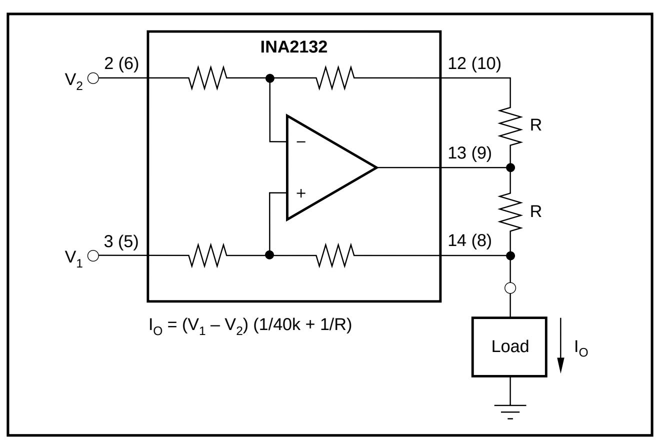


FIGURE 7. Precision Voltage-to-Current Converter with Differential Inputs.

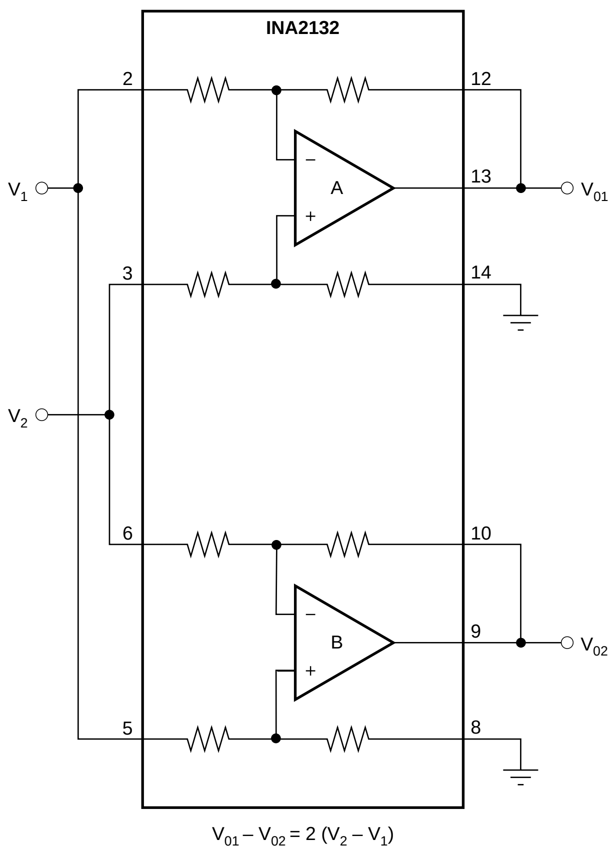


FIGURE 8. Differential Output Difference Amplifier.

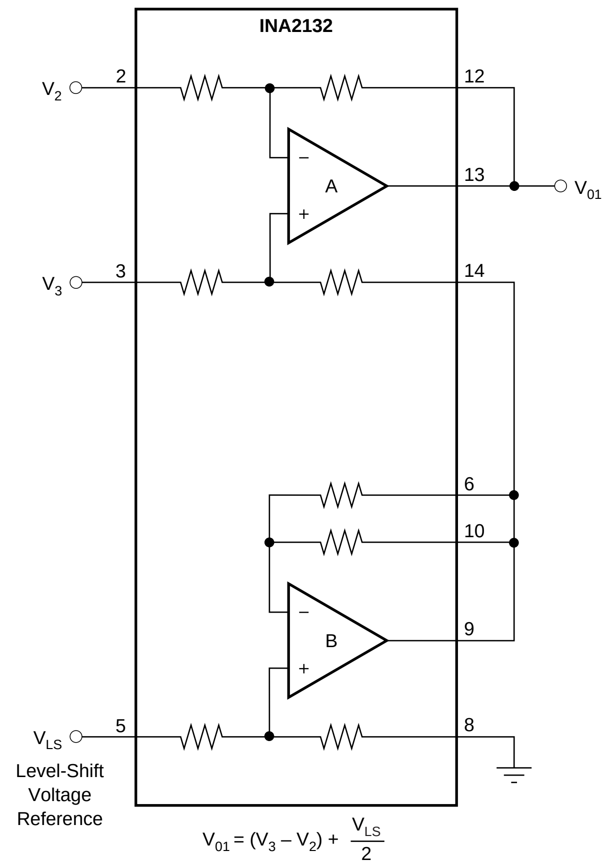
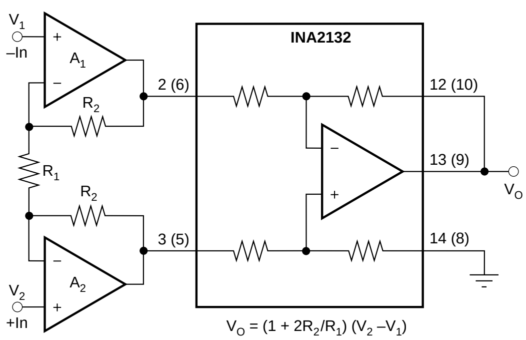


FIGURE 9. Precision Level Shifter.



The INA2132 can be combined with op amps to form a complete instrumentation amplifier with specialized performance characteristics. Burr-Brown offers many complete high performance IAs. Products with similar performances are shown below.

A_1, A_2	FEATURES	SIMILAR COMPLETE BURR-BR0WN IAs
OPA227	Low Noise	INA103
OPA129	Ultra-Low Bias Current (fA)	INA116
OPA2277	Low Offset Drift, Low Noise	INA114, INA128
OPA2130	Low Power, FET-Input (pA)	INA121
OPA2234, OPA2241, OPA2244	Single Supply, Precision, Low Power	INA122, INA118
OPA2237	Single Supply, Low Power, MSOP-8	INA122, INA126

FIGURE 10. Precision Instrumentation Amplifier.

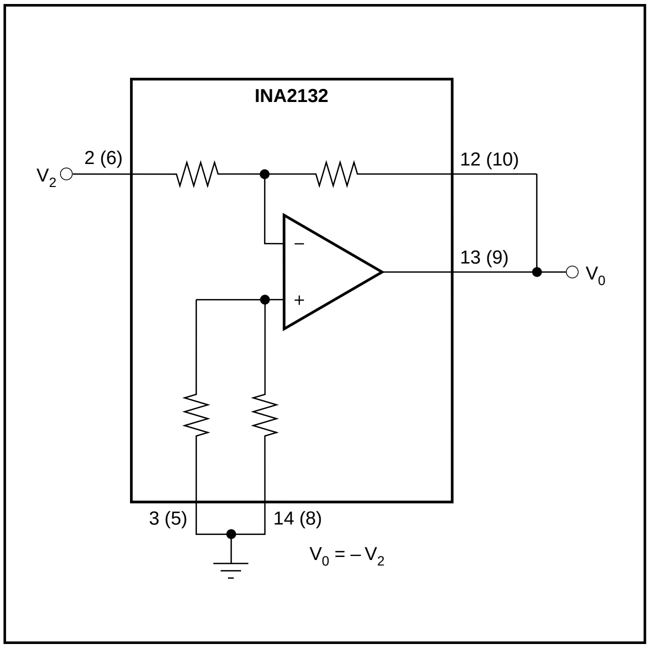


FIGURE 11. Precision Inverting Unity-Gain Amplifier.

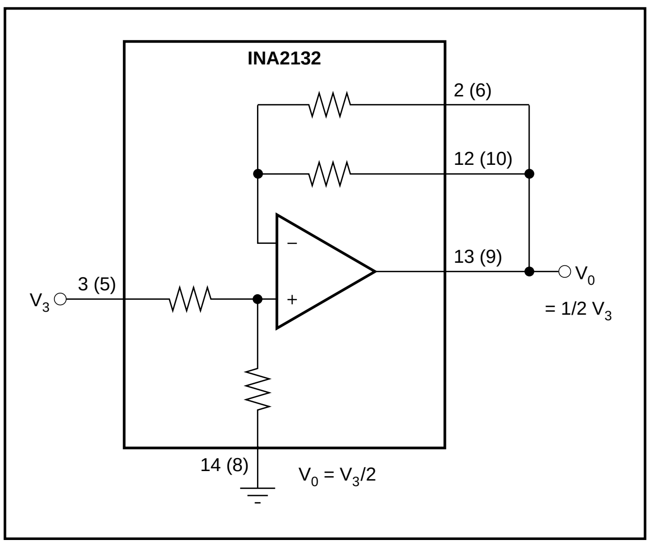


FIGURE 12. Precision Gain = 1/2 Amplifier.

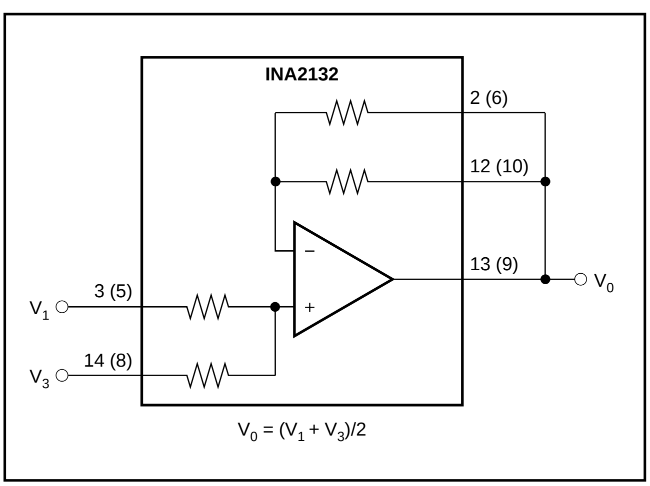


FIGURE 13. Precision Average Value Amplifier.

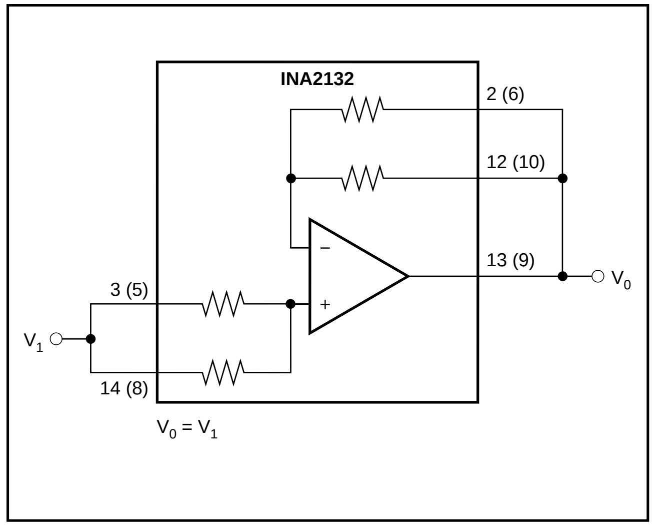


FIGURE 14. Precision Unity-Gain Buffer.

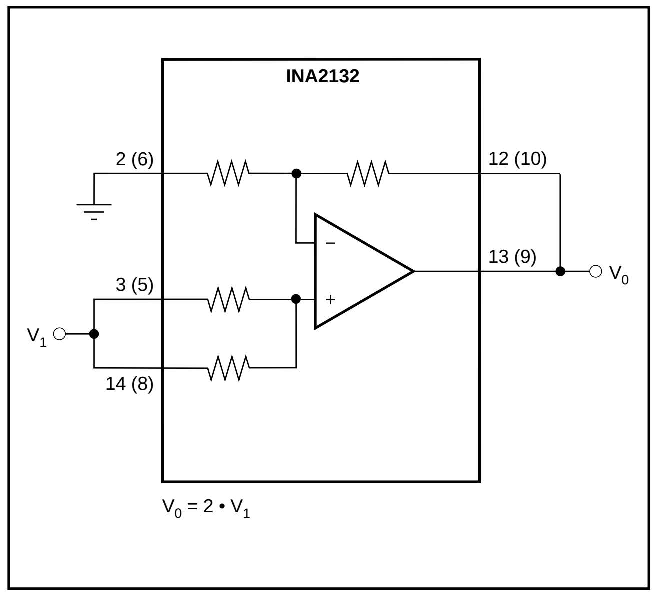


FIGURE 15. Precision Gain = 2 Amplifier.

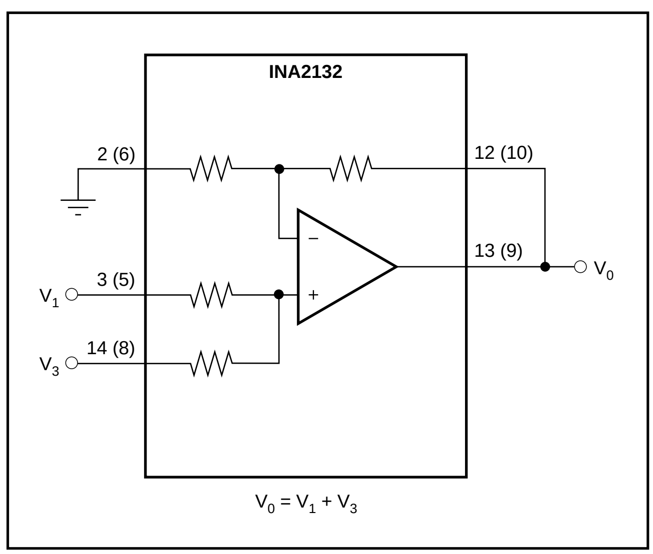


FIGURE 16. Precision Summing Amplifier.

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/ Ball Finish	MSL Peak Temp [3]	Samples (Requires Login)
INA2132U	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	
INA2132U/2K5	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	
INA2132UA	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	
INA2132UA/2K5	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	
INA2132UA/2K5E4	OBSOLETE	SOIC	D	14		TBD	Call TI	Call TI	
INA2132UA/2K5G4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	
INA2132UAE4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	
INA2132UAG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	
INA2132UE4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	
INA2132UG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	

[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] 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)

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

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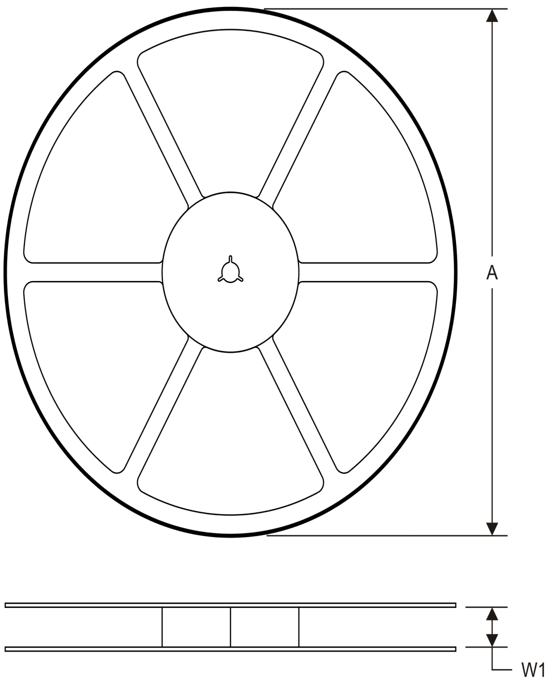
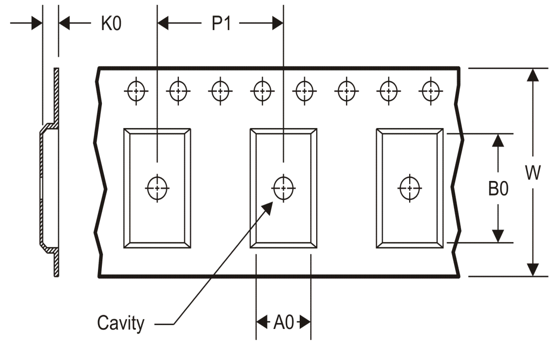
TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



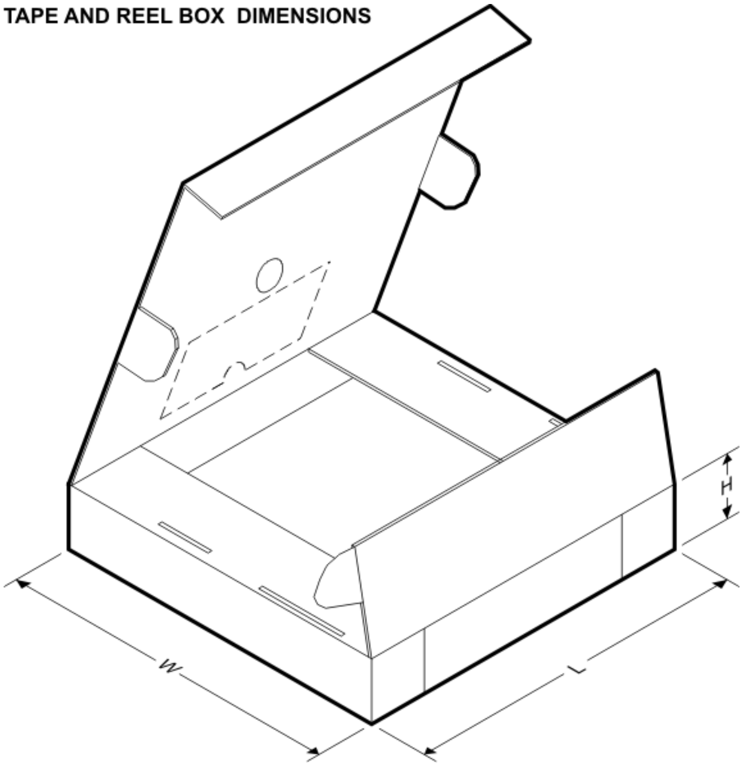
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

TAPE AND REEL INFORMATION

*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
INA2132U/2K5	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
INA2132UA/2K5	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1

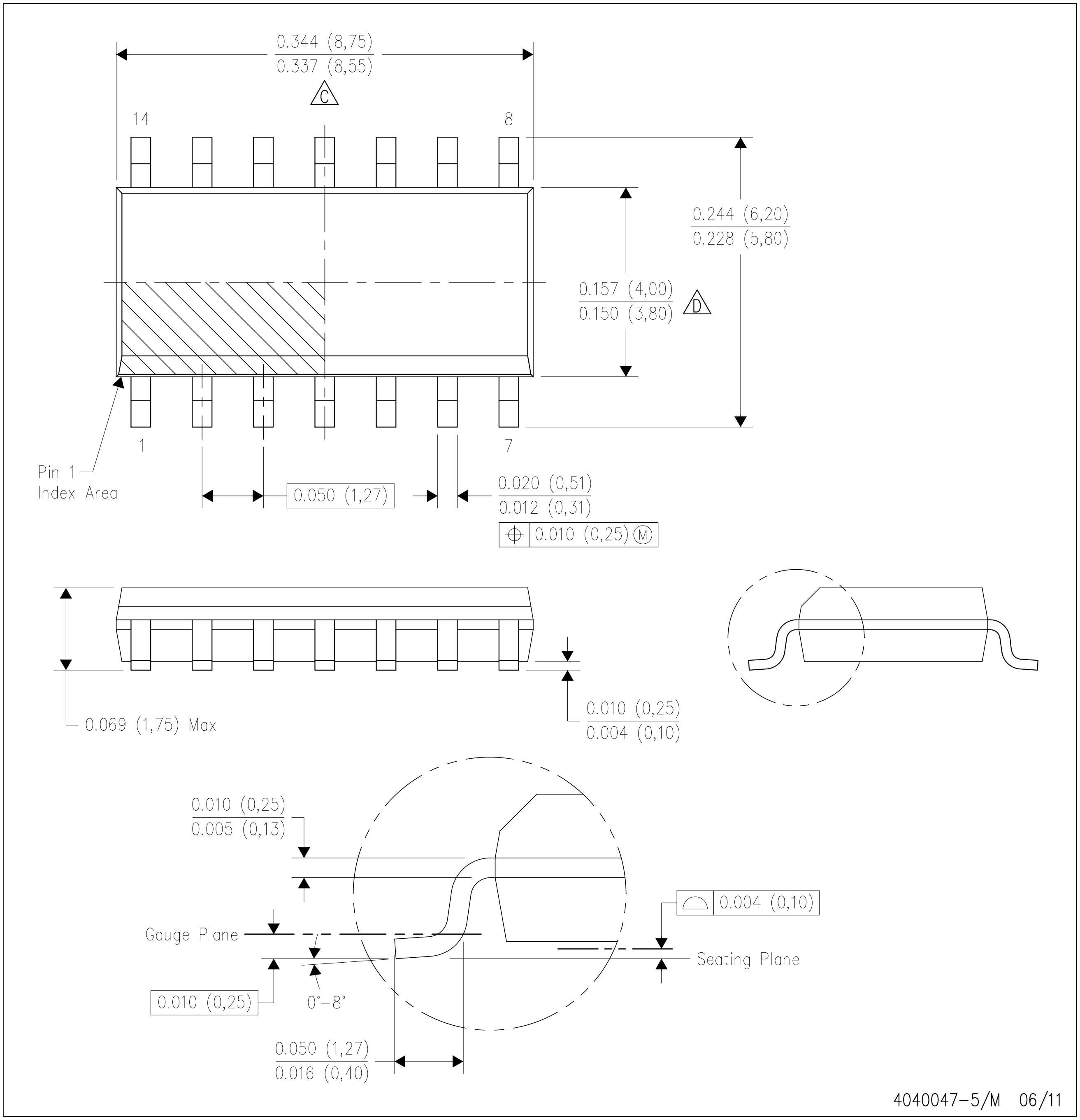
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

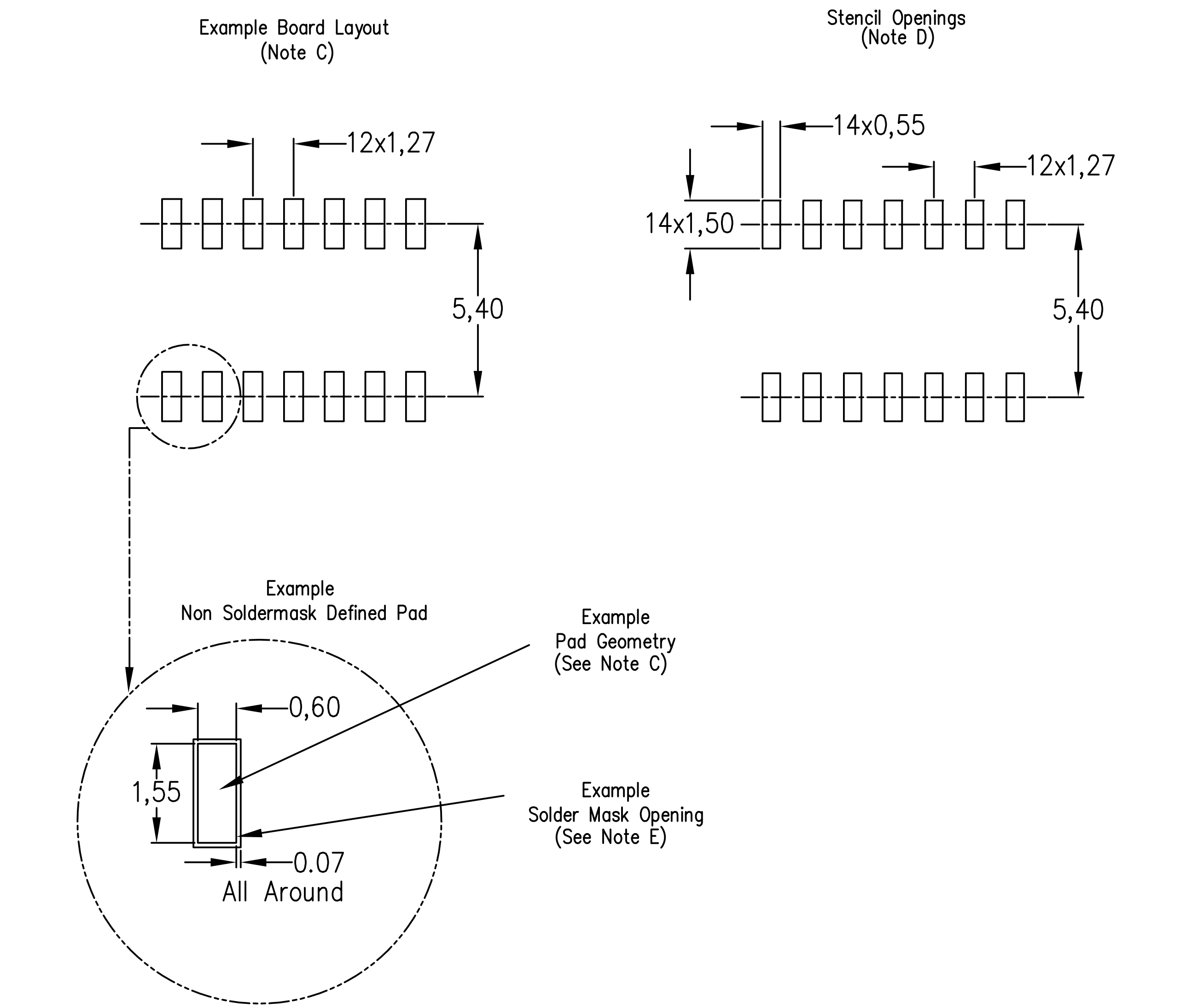
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
INA2132U/2K5	SOIC	D	14	2500	367.0	367.0	38.0
INA2132UA/2K5	SOIC	D	14	2500	367.0	367.0	38.0

D (R–PDSO–G14) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS-012 variation AB.

D (R-PDSO-G14) PLASTIC SMALL OUTLINE



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NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Publication IPC-7351 is recommended for alternate designs.
- D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
- E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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