

SBOS152A – AUGUST 1987 – REVISED OCTOBER 2003

## Precision Gain = 10 DIFFERENTIAL AMPLIFIER

### FEATURES

- ACCURATE GAIN:  $\pm 0.025\%$  max
- HIGH COMMON-MODE REJECTION: 86dB min
- NONLINEARITY: 0.001% max
- EASY TO USE
- PLASTIC 8-PIN DIP, SO-8 SOIC PACKAGES

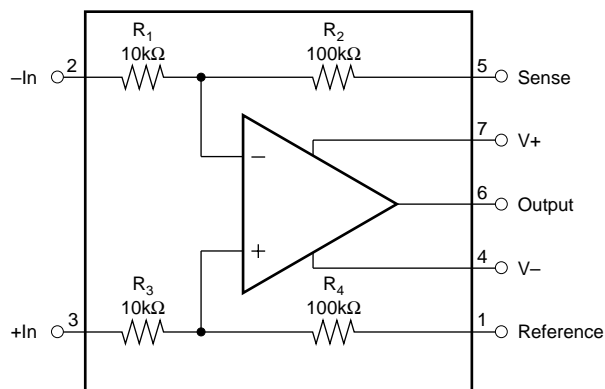
### APPLICATIONS

- G = 10 DIFFERENTIAL AMPLIFIER
- G = +10 AMPLIFIER
- G = -10 AMPLIFIER
- G = +11 AMPLIFIER
- INSTRUMENTATION AMPLIFIER

### DESCRIPTION

The INA106 is a monolithic Gain = 10 differential amplifier consisting of a precision op amp and on-chip metal film resistors. The 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 differential amplifier is the foundation of many commonly used circuits. The INA106 provides this precision circuit function without using an expensive resistor network. The INA106 is available in 8-pin plastic DIP and SO-8 surface-mount packages.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.

# SPECIFICATIONS

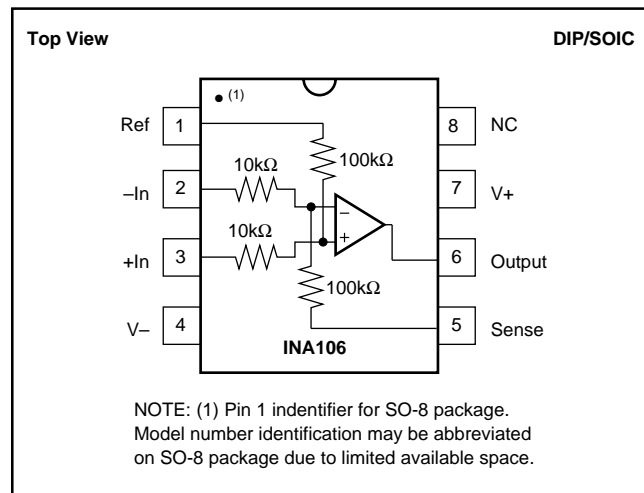
## ELECTRICAL

At +25°C,  $V_S = \pm 15V$ , unless otherwise specified.

PARAMETER	CONDITIONS	INA106KP, U			UNITS
		MIN	TYP	MAX	
<b>GAIN</b> Initial <sup>(1)</sup> Error vs Temperature Nonlinearity <sup>(2)</sup>			10 0.01 -4 0.0002	0.025	V/V % ppm/°C %
<b>OUTPUT</b> Related Voltage Rated Current Impedance Current Limit Capacitive Load	$I_O = +20mA, -5mA$ $V_O = 10V$  To Common Stable Operation	10 +20, -5	12  0.01 +40/-10 1000		V mA $\Omega$ mA pF
<b>INPUT</b> Impedance  Voltage Range  Common-Mode Rejection <sup>(3)</sup>	Differential Common-Mode Differential Common-Mode $T_A = T_{MIN}$ to $T_{MAX}$		10 110   86		k $\Omega$ k $\Omega$ V V dB
<b>OFFSET VOLTAGE</b> Initial vs Temperature vs Supply vs Time	RTI <sup>(4)</sup>  $\pm V_S = 6V$ to $18V$		50 0.2 1 10	200  10	$\mu V$ $\mu V/^\circ C$ $\mu V/V$ $\mu V/mo$
<b>NOISE VOLTAGE</b> $f_B = 0.01Hz$ to $10Hz$ $f_O = 10kHz$	RTI <sup>(5)</sup>		1 30		$\mu Vp-p$ nV/ $\sqrt{Hz}$
<b>DYNAMIC RESPONSE</b> Small Signal Full Power BW Slew Rate Settling Time: 0.1% 0.01% 0.01%	-3dB $V_O = 20Vp-p$  $V_O = 10V$ Step $V_O = 10V$ Step $V_{CM} = 10V$ Step, $V_{DIFF} = 0V$	30 2	5 50 3 5 10 5		MHz kHz V/ $\mu s$ $\mu s$ $\mu s$ $\mu s$
<b>POWER SUPPLY</b> Rated Voltage Range Quiescent Current	Derated Performance $V_O = 0V$	$\pm 5$	$\pm 15$  $\pm 1.5$	$\pm 18$  $\pm 2$	V V mA
<b>TEMPERATURE RANGE</b> Specification Operation Storage		0 -40 -65		+70 +85 +150	°C °C °C

NOTES: (1) Connected as difference amplifier (see Figure 1). (2) Nonlinearity is the maximum peak deviation from the best-fit straight line as a percent of full-scale peak-to-peak output. (3) With zero source impedance (see "Maintaining CMR" section). (4) Includes effects of amplifiers' input bias and offset currents. (5) Includes effect of amplifier's input current noise and thermal noise contribution of resistor network.

## PIN CONFIGURATION



## ABSOLUTE MAXIMUM RATINGS

Power Supply Voltage .....	±18V
Input Voltage Range .....	±V <sub>S</sub>
Operating Temperature Range: P, U .....	-40°C to +85°C
Storage Temperature Range .....	-40°C to +85°C
Lead Temperature (soldering, 10s): P .....	+300°C
Wave Soldering (3s, max) U .....	+260°C
Output Short Circuit to Common .....	Continuous

NOTE: (1) Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. Exposure to absolute maximum conditions for extended periods may affect device reliability.



## ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Texas Instruments 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.

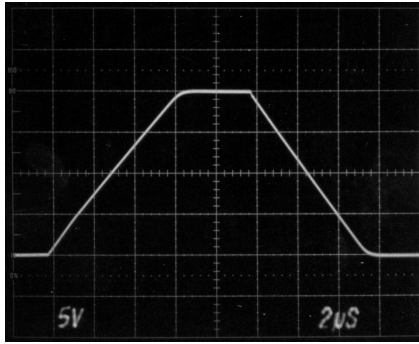
## PACKAGE/ORDERING INFORMATION

For the most current package and ordering information, see the Package Option Addendum located at the end of this data sheet.

# TYPICAL PERFORMANCE CURVES

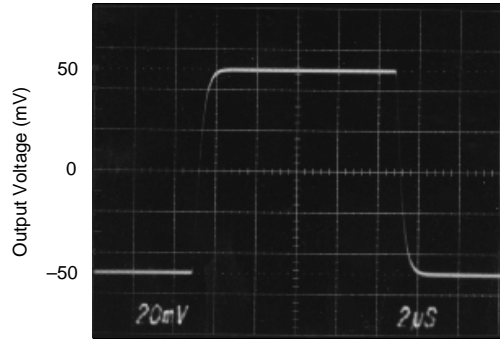
At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 15\text{V}$ , unless otherwise noted.

STEP RESPONSE



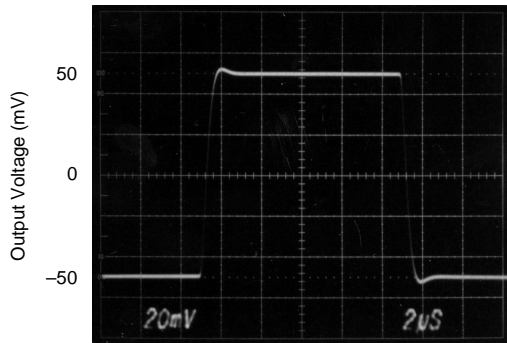
2µs/div

SMALL SIGNAL RESPONSE  
(No Load)



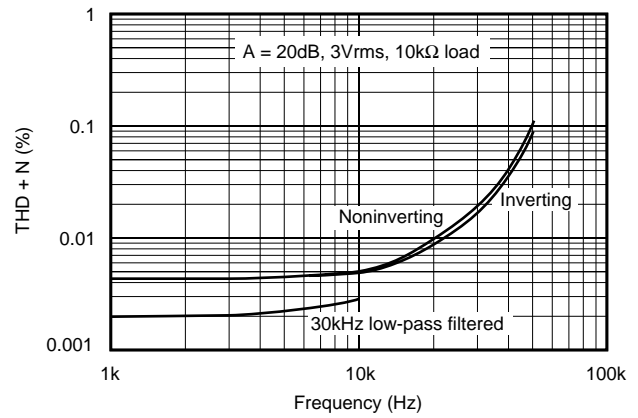
2µs/div

SMALL SIGNAL RESPONSE  
( $R_{LOAD} = \infty$ ,  $C_{LOAD} = 100\text{pF}$ )

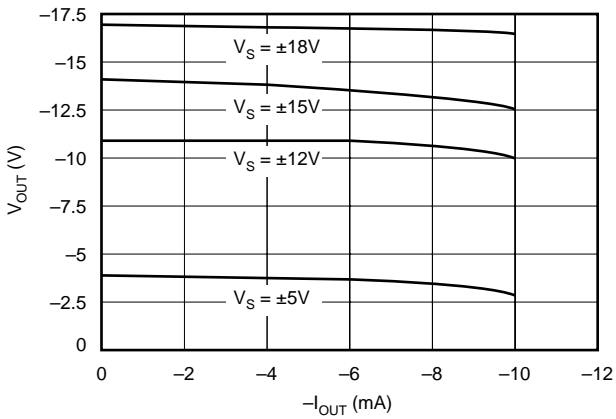


2µs/div

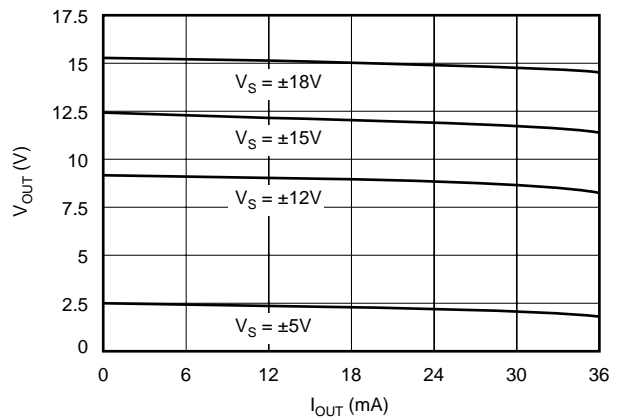
TOTAL HARMONIC DISTORTION AND NOISE  
vs FREQUENCY



MAXIMUM  $V_{OUT}$  vs  $I_{OUT}$   
(Negative Swing)

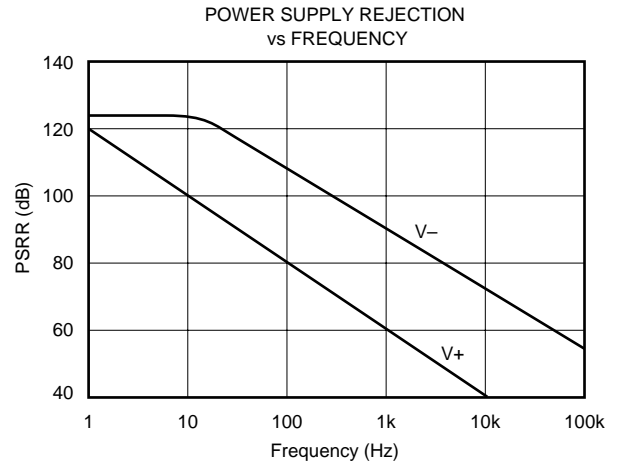
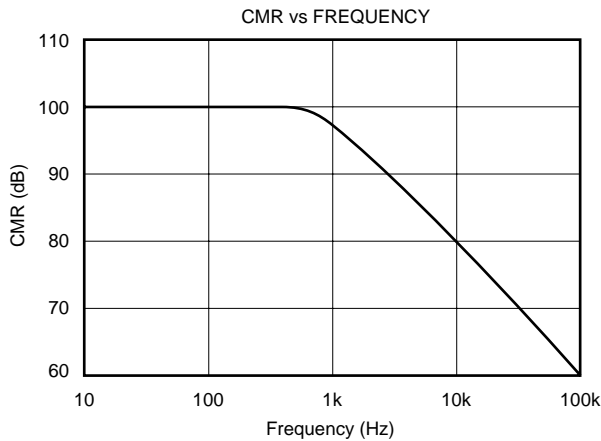


MAXIMUM  $V_{OUT}$  vs  $I_{OUT}$   
(Positive Swing)



# TYPICAL PERFORMANCE CURVES (CONT)

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



## APPLICATIONS INFORMATION

Figure 1 shows the basic connections required for operation of the INA106. Power supply bypass capacitors should be connected close to the device pins as shown.

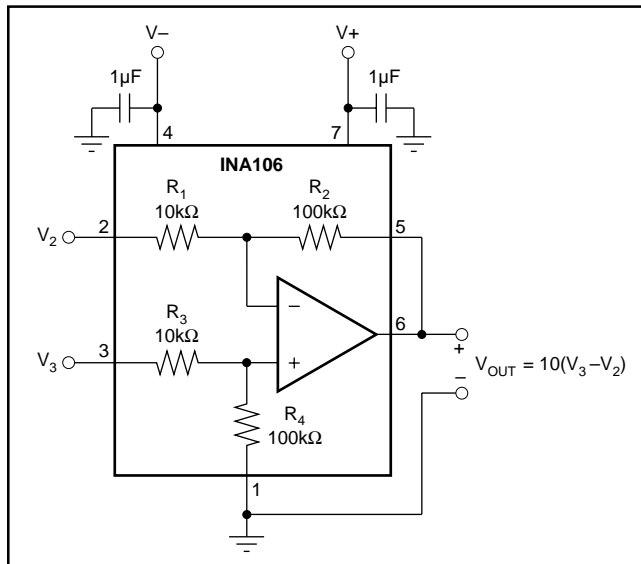


FIGURE 1. Basic Power Supply and Signal Connections.

The differential input signal is connected to pins 2 and 3 as shown. The source impedance connected to the inputs must be 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 86dB. If the source has a known source impedance mismatch, an additional resistor in series with one input can be used to preserve good common-mode rejection.

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. 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 shows a voltage applied to pin 1 to trim the offset voltage of the INA106. The known  $100\Omega$  source impedance of the trim circuit is compensated by the  $10\Omega$  resistor in series with pin 3 to maintain good CMR.

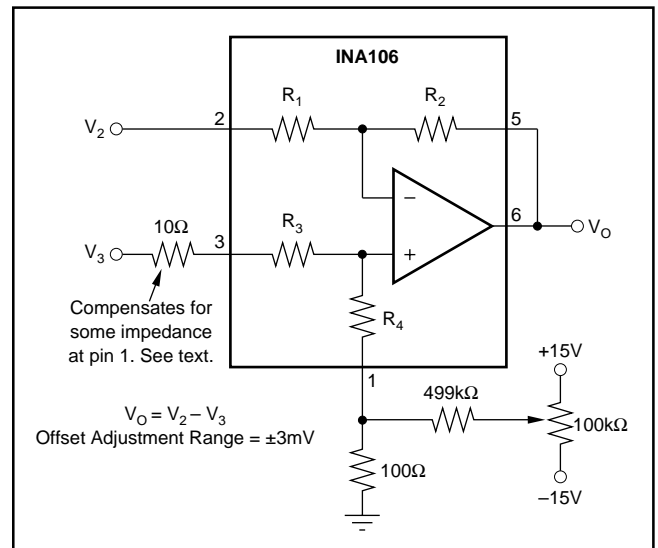


FIGURE 2. Offset Adjustment.

Referring to Figure 1, the CMR depends upon the match of the internal  $R_4/R_3$  ratio to the  $R_1/R_2$  ratio. A CMR of 106dB requires resistor matching of 0.005%. To maintain high CMR over temperature, the resistor TCR tracking must be better than  $2\text{ppm}/^\circ\text{C}$ . These accuracies are difficult and expensive to reliably achieve with discrete components.

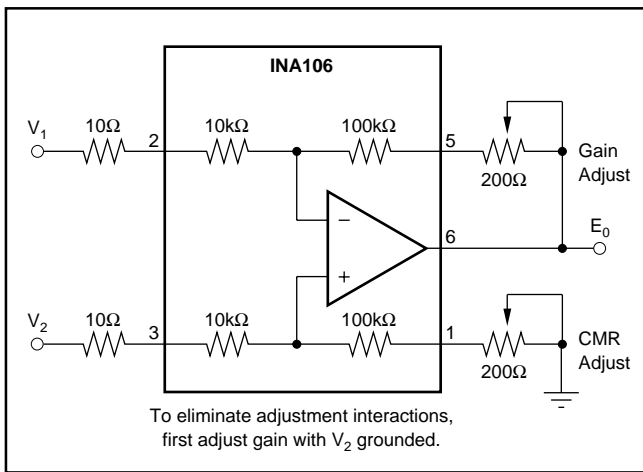


FIGURE 3. Difference Amplifier with Gain and CMR Adjust.

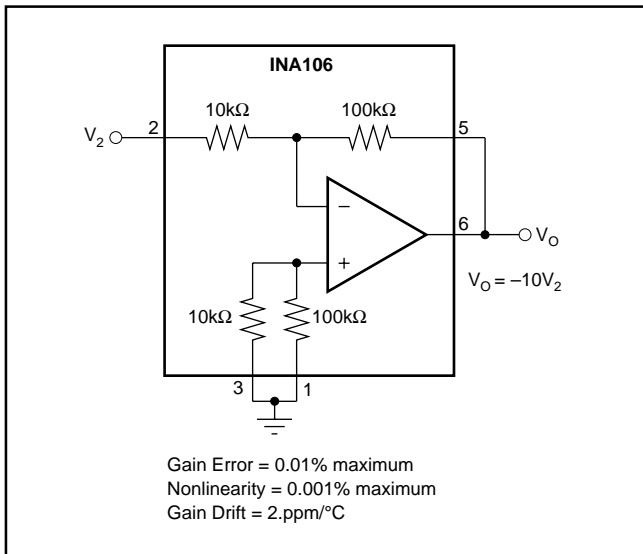


FIGURE 4. Precision  $G = -10$  Inverting Amplifier.

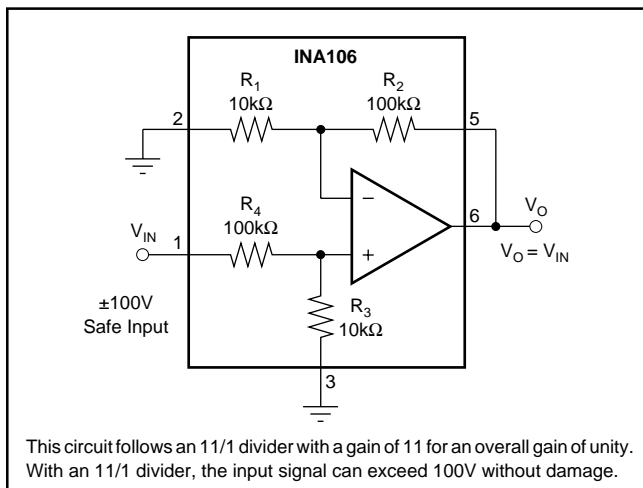
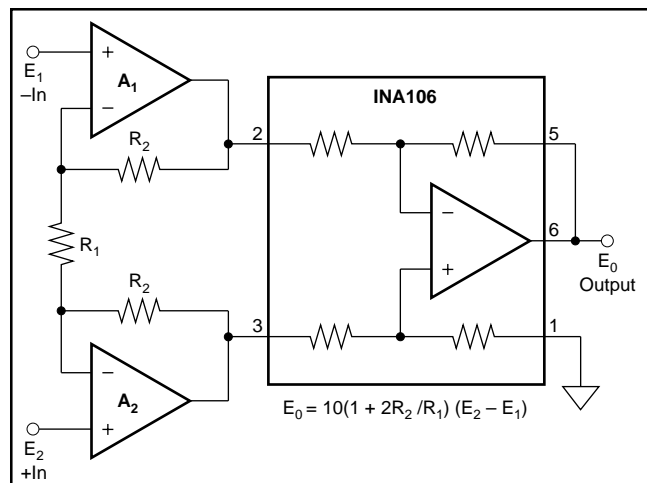


FIGURE 5. Voltage Follower with Input Protection.



To make a high performance high gain instrumentation amplifier, the INA106 can be combined with state-of-the-art op amps. For low source impedance applications, OPA37s will give the best noise, offset, and temperature drift. At source impedances above about 10kΩ, the bias current noise of the OPA37 reacting with input impedance degrades noise. For these applications, use an OPA111 or a dual OPA2111 FET input op amp for lower noise. For an electrometer grade IA, use the OPA128—see table below.

Using the INA106 for the difference amplifier also extends the input common-mode range of the instrumentation amplifier to ±10V. A conventional IA with a unity-gain difference amplifier has an input common-mode range limited to ±5V for an output swing of ±10V. This is because a unity-gain difference amp needs ±5V at the input for 10V at the output, allowing only 5V additional for common-mode.

A <sub>1</sub> , A <sub>2</sub>	R <sub>1</sub> (Ω)	R <sub>2</sub> (kΩ)	GAIN (V/V)	CMRR (dB)	I <sub>b</sub> (pA)	NOISE AT 1kHz (nV/√Hz)
OPA37A	50.5	2.5	1000	128	40000	4
OPA111B	202	10	1000	110	1	10
OPA128LM	202	10	1000	118	0.075	38

FIGURE 6. Precision Instrumentation Amplifier.

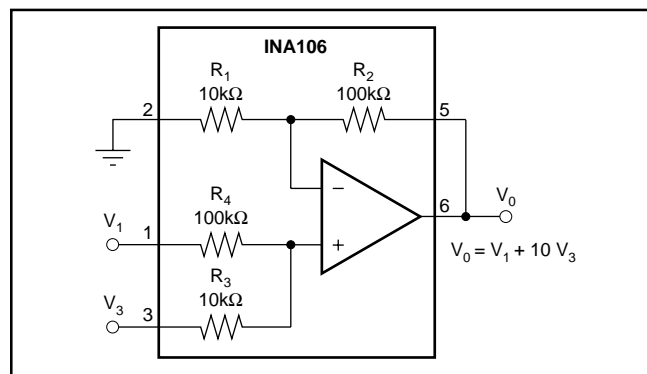


FIGURE 7. Precision Summing Amplifier.

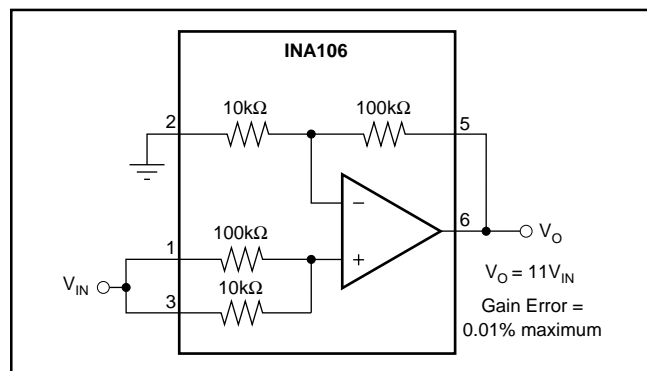


FIGURE 8. Precision  $G = 11$  Buffer.

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
INA106KP	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type
INA106KPG4	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type
INA106U	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA106U/2K5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA106U/2K5G4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA106UE4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR

<sup>(1)</sup> 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.

<sup>(2)</sup> 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)

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

**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**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
INA106U/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)
INA106U/2K5	SOIC	D	8	2500	367.0	367.0	35.0

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Falls within JEDEC MS-001 variation BA.

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



- 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.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

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 relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Applications Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

### TI E2E Community

[e2e.ti.com](http://e2e.ti.com)



## Стандарт Электрон Связь

Мы молодая и активно развивающаяся компания в области поставок электронных компонентов. Мы поставляем электронные компоненты отечественного и импортного производства напрямую от производителей и с крупнейших складов мира.

Благодаря сотрудничеству с мировыми поставщиками мы осуществляем комплексные и плановые поставки широчайшего спектра электронных компонентов.

Собственная эффективная логистика и склад в обеспечивает надежную поставку продукции в точно указанные сроки по всей России.

Мы осуществляем техническую поддержку нашим клиентам и предпродажную проверку качества продукции. На все поставляемые продукты мы предоставляем гарантию .

Осуществляем поставки продукции под контролем ВП МО РФ на предприятия военно-промышленного комплекса России , а также работаем в рамках 275 ФЗ с открытием отдельных счетов в уполномоченном банке. Система менеджмента качества компании соответствует требованиям ГОСТ ISO 9001.

Минимальные сроки поставки, гибкие цены, неограниченный ассортимент и индивидуальный подход к клиентам являются основой для выстраивания долгосрочного и эффективного сотрудничества с предприятиями радиоэлектронной промышленности, предприятиями ВПК и научно-исследовательскими институтами России.

С нами вы становитесь еще успешнее!

### Наши контакты:

**Телефон:** +7 812 627 14 35

**Электронная почта:** [sales@st-electron.ru](mailto:sales@st-electron.ru)

**Адрес:** 198099, Санкт-Петербург,  
Промышленная ул, дом № 19, литера Н,  
помещение 100-Н Офис 331