



# INA105

# Precision Unity Gain DIFFERENTIAL AMPLIFIER

### **FEATURES**

- CMR 86dB min OVER TEMPERATURE
- GAIN ERROR: 0.01% max
- NONLINEARITY: 0.001% max
- NO EXTERNAL ADJUSTMENTS REQUIRED
- EASY TO USE
- COMPLETE SOLUTION
- HIGHLY VERSATILE
- LOW COST
- PLASTIC DIP, TO-99 HERMETIC METAL, AND SO-8 SOIC PACKAGES

### APPLICATIONS

- DIFFERENTIAL AMPLIFIER
- INSTRUMENTATION AMPLIFIER
   BUILDING BLOCK
- UNITY-GAIN INVERTING AMPLIFIER
- GAIN-OF-1/2 AMPLIFIER
- NONINVERTING GAIN-OF-2 AMPLIFIER
- AVERAGE VALUE AMPLIFIER
- ABSOLUTE VALUE AMPLIFIER
- SUMMING AMPLIFIER
- SYNCHRONOUS DEMODULATOR
- CURRENT RECEIVER WITH COMPLIANCE TO RAILS
- 4mA TO 20mA TRANSMITTER
- VOLTAGE-CONTROLLED CURRENT SOURCE
- ALL-PASS FILTERS

# DESCRIPTION

The INA105 is a monolithic Gain = 1 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 INA105 provides this precision circuit function without using an expensive precision resistor network. The INA105 is available in 8-pin plastic DIP, SO-8 surface-mount and TO-99 metal packages.



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# **SPECIFICATIONS**

#### ELECTRICAL

At +25°C,  $V_{CC} = \pm 15V$ , unless otherwise noted.

			INA105AM	I		INA105B	И	IN	IA105KP,	κU	
PARAMETER	CONDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	MIN	ТҮР	MAX	UNITS
GAIN Initial <sup>(1)</sup> Error vs Temperature Nonlinearity <sup>(2)</sup>			1 0.005 1 0.0002	0.01 5 0.001		* * * *	* * *		* 0.01 * *	0.025 * *	V/V % ppm/°C %
OUTPUT Rated Voltage Rated Current Impedance Current Limit Capacitive Load	l <sub>O</sub> = +20mA, –5mA V <sub>O</sub> = 10V To Common Stable Operation	10 +20, –5	12 0.01 +40/-10 1000		* *	* * *		* *	* * * *		V mA Ω mA pF
INPUT Impedance <sup>(3)</sup> Voltage Range <sup>(4)</sup> Common-Mode Rejection <sup>(5)</sup>	Differential Common-Mode Differential Common-Mode $T_A = T_{MIN}$ to $T_{MAX}$	±10 ±20 80	50 50 90		* * 86	* * 100		* * 72	* *		kΩ kΩ V V dB
OFFSET VOLTAGE Initial vs Temperature vs Supply vs Time	$RTO^{(6)}$ , (7) $\pm V_{S} = 6V \text{ to } 18V$		50 5 1 20	250 20 25		* 5 * *	* 10 15		* * * *	500 * *	μV μV/°C μV/V μV/No
OUTPUT NOISE VOLTAGE $f_B = 0.01Hz$ to 10Hz $f_O = 10kHz$	RTO <sup>(6), (8)</sup>		2.4 60			* *			* *		μVp-p nV/√Hz
DYNAMIC RESPONSE Small Signal Bandwidth Full Power Bandwidth Slew Rate Settling Time: 0.1% 0.01% 0.01% V	$-3dB$ $V_{O} = 20Vp-p$ $V_{O} = 10V \text{ Step}$ $V_{O} = 10V \text{ Step}$ $C_{M} = 10V \text{ Step}, V_{DIFF} = 0$	30 2	1 50 3 4 5 1.5		* *	* * * * *		* *	* * * * *		MHz kHz V/μs μs μs μs
POWER SUPPLY Rated Voltage Range Quiescent Current	Derated Performance V <sub>O</sub> = 0V	±5	±15 ±1.5	±18 ±2	*	*	* *	*	*	* *	V V mA
TEMPERATURE RANGE Specification Operation Storage		-40 -55 -65		+85 +125 +150	* * *		* * *	* -40 -40		* +85 +125	0° ⊃° ⊃°

\* Specification same as for INA105AM.

NOTES: (1) Connected as difference amplifier (see Figure 4). (2) Nonlinearity is the maximum peak deviation from the best-fit straight line as a percent of full-scale peakto-peak output. (3)  $25k\Omega$  resistors are ratio matched but have  $\pm 20\%$  absolute value. (4) Maximum input voltage without protection is 10V more than either  $\pm 15V$  supply ( $\pm 25V$ ). Limit I<sub>IN</sub> to 1mA. (5) With zero source impedance (see "Maintaining CMR" section). (6) Referred to output in unity-gain difference configuration. Note that this circuit has a gain of 2 for the operational amplifier's offset voltage and noise voltage. (7) Includes effects of amplifier's input bias and offset currents. (8) Includes effects of amplifier's input current noise and thermal noise contribution of resistor network.

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#### **PIN CONFIGURATIONS**



#### **ABSOLUTE MAXIMUM RATINGS**

Supply	±18V
Input Voltage Range	±V <sub>S</sub>
Operating Temperature Range: M	–55°C to +125°C
P, U	40°C to +85°C
Storage Temperature Range: M	–65°C to +150°C
P, U	40°C to +125°C
Lead Temperature (soldering, 10s) M, P	+300°C
Wave Soldering (3s, max) U	+260°C
Output Short Circuit to Common	Continuous

#### **PACKAGE/ORDERING INFORMATION**

PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER <sup>(1)</sup>	TEMPERATURE RANGE
INA105AM	TO-99 Metal	001	-40°C to +85°C
INA105BM	TO-99 Metal	001	-40°C to +85°C
INA105KP	8-Pin Plastic DIP	006	-40°C to +85°C
INA105KU	8-Pin SOIC	182	–40°C to +85°C

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



## 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.



**INA105** 

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# **TYPICAL PERFORMANCE CURVES**

At  $T_A$  = 25°C,  $V_S$  =  $\pm 15V,$  unless otherwise noted.

















### **TYPICAL PERFORMANCE CURVES (CONT)**

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





### **APPLICATION INFORMATION**

Figure 1 shows the basic connections required for operation of the INA105. Power supply bypass capacitors should be connected close to the device pins.

The differential input signal is connected to pins 2 and 3 as shown. 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 80dB. If the source has a known mismatch in source impedance, 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. This can be used to null offset voltage as shown in Figure 2. The source impedance of a signal applied to the Ref terminal should be less than  $10\Omega$  to maintain good common-mode rejection.

Do not interchange pins 1 and 3 or pins 2 and 5, even though nominal resistor values are equal. These resistors are laser trimmed for precise resistor ratios to achieve accurate gain and highest CMR. Interchanging these pins would not provide specified performance.



FIGURE 1. Basic Power Supply and Signal Connections.





FIGURE 2. Offset Adjustment.



FIGURE 3. Precision Difference Amplifier.



For low source impedance applications, an input stage using OPA27 op amps will give the best low noise, offset, and temperature drift performance. At source impedances above about 10kΩ, the bias current noise of the OPA27 reacting with the input impedance begins to dominate the noise performance. For these applications, using the OPA111 or dual OPA2111 FET input op amp will provide lower noise performance. For lower cost use the OPA121 plastic. To construct an electrometer use the OPA128.

A <sub>1</sub> , A <sub>2</sub>	R <sub>1</sub> (Ω)	R₂ (Ω)	GAIN (V/V)	CMRR (dB)	MAX I <sub>B</sub>	NOISE AT 1kHz (nV/\HZ)
OPA27A	50.5	2.5k	100	128	40nA	4
OPA111B	202	10k	100	110	1pA	10
OPA128LM	202	10k	100	118	75fA	38

FIGURE 4. Precision Instrumentation Amplifier.



FIGURE 5. Current Receiver with Compliance to Rails.

BURR-BROWN® INA105



FIGURE 6. Precision Unity-Gain Inverting Amplifier.



FIGURE 7. ±10V Precision Voltage Reference.



FIGURE 8. ±5V Precision Voltage Reference.



FIGURE 9. Precision Unity-Gain Buffer.



FIGURE 10. Pseudoground Generator.



FIGURE 11. Precision Average Value Amplifier.



**INA105** 



FIGURE 12. Precision (G = 2) Amplifier.



FIGURE 13. Precision Summing Amplifier.



FIGURE 14. Precision Gain = 1/2 Amplifier.





FIGURE 15. Precision Bipolar Offsetting.



FIGURE 16. Precision Summing Amplifier with Gain.



FIGURE 17. Instrumentation Amplifier Guard Drive Generator.



FIGURE 18. Precision Summing Instrumentation Amplifier.





FIGURE 19. Precision Voltage-to-Current Converter with Differential Inputs.



FIGURE 20. Differential Input Voltage-to-Current Converter for Low  $I_{OUT}$ .



FIGURE 21. Isolating Current Source.





FIGURE 22. Differential Output Difference Amplifier.



FIGURE 23. Isolating Current Source with Buffering Amplifier for Greater Accuracy.



FIGURE 24. Window Comparator with Window Span and Window Center Inputs.







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FIGURE 26. Digitally Controlled Gain of ±1 Amplifier.





FIGURE 27. Boosting Instrumentation Amplifier Common-Mode Range From ±5 to ±7.5V with 10V Full-Scale Output.



FIGURE 28. Precision Absolute Value Buffer.



FIGURE 29. Precision 4-20mA Current Transmitter.





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#### **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>	Samples (Requires Login)
INA105AM	NRND	TO-99	LMC	8	20	Green (RoHS & no Sb/Br)	AU	N / A for Pkg Type	Samples Not Available
INA105BM	NRND	TO-99	LMC	8	1	Green (RoHS & no Sb/Br)	AU	N / A for Pkg Type	Samples Not Available
INA105KP	ACTIVE	PDIP	Р	8	50	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type	Contact TI Distributor or Sales Office
INA105KPG4	ACTIVE	PDIP	Р	8	50	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type	Contact TI Distributor or Sales Office
INA105KU	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	Contact TI Distributor or Sales Office
INA105KU/2K5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	Purchase Samples
INA105KU/2K5E4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	Purchase Samples
INA105KUE4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	Contact TI Distributor or Sales Office

<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.

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



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25-Aug-2010

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#### TAPE AND REEL INFORMATION





### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All c	dimensions	are	nominal
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Device	Package Type	Package Drawing			Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
INA105KU/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1



### PACKAGE MATERIALS INFORMATION

11-Mar-2008



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
INA105KU/2K5	SOIC	D	8	2500	346.0	346.0	29.0

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