

**PGA103**

## Programmable Gain AMPLIFIER

### FEATURES

- DIGITALLY PROGRAMMABLE GAINS:  
G=1, 10, 100V/V
- CMOS/TTL-COMPATIBLE INPUTS
- LOW GAIN ERROR:  $\pm 0.05\%$  max, G=10
- LOW OFFSET VOLTAGE DRIFT:  $2\mu\text{V}/^\circ\text{C}$
- LOW QUIESCENT CURRENT: 2.6mA
- LOW COST
- 8-PIN PLASTIC DIP, SO-8 PACKAGES

### APPLICATIONS

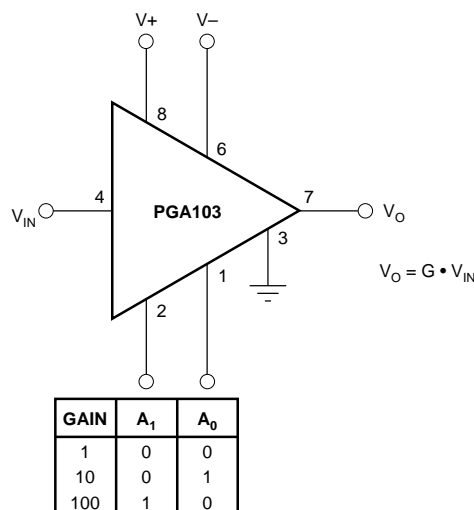
- DATA ACQUISITION SYSTEMS
- GENERAL PURPOSE ANALOG BOARDS
- MEDICAL INSTRUMENTATION

### DESCRIPTION

The PGA103 is a programmable-gain amplifier for general purpose applications. Gains of 1, 10, or 100 are digitally selected by two CMOS/TTL-compatible inputs. The PGA103 is ideal for systems that must handle wide dynamic range signals.

The PGA103's high speed circuitry provides fast settling time, even at G=100 ( $8\mu\text{s}$  to 0.01%). Bandwidth is 250kHz at G=100, yet quiescent current is only 2.6mA. It operates from  $\pm 4.5\text{V}$  to  $\pm 18\text{V}$  power supplies.

The PGA103 is available in 8-pin plastic DIP and SO-8 surface-mount packages, specified for the  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$  temperature range.



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# SPECIFICATIONS

## ELECTRICAL

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

PARAMETER	CONDITIONS	PGA103P, U			UNITS
		MIN	TYP	MAX	
<b>INPUT</b> Offset Voltage, RTI G = 1 G = 10 G = 100 vs Temperature G = 1 G = 10 G = 100 vs Power Supply G = 1 G = 10 G = 100 Impedance	$T_A = +25^\circ\text{C}$  $T_A = T_{\text{MIN}}$ to $T_{\text{MAX}}$  $V_S = \pm 4.5\text{V}$ to $\pm 18\text{V}$		$\pm 200$ $\pm 100$ $\pm 100$  $\pm 5$ $\pm 2$ $\pm 2$  30 10 10 $10^8 \parallel 2$	$\pm 1500$ $\pm 500$ $\pm 500$      70 35 35	$\mu\text{V}$ $\mu\text{V}$ $\mu\text{V}$  $\mu\text{V}/^\circ\text{C}$ $\mu\text{V}/^\circ\text{C}$ $\mu\text{V}/^\circ\text{C}$  $\mu\text{V}/\text{V}$ $\mu\text{V}/\text{V}$ $\mu\text{V}/\text{V}$ $\Omega \parallel \text{pF}$
<b>INPUT BIAS CURRENT</b> Initial Bias Current vs Temperature			$\pm 50$ $\pm 100$	$\pm 150$	nA pA/ $^\circ\text{C}$
<b>NOISE VOLTAGE, RTI</b> f = 10Hz f = 100Hz f = 1kHz f <sub>B</sub> = 0.1Hz to 10Hz	G = 100, R <sub>S</sub> = 0 $\Omega$		16 11 11 0.6		nV/ $\sqrt{\text{Hz}}$ nV/ $\sqrt{\text{Hz}}$ nV/ $\sqrt{\text{Hz}}$ $\mu\text{Vp-p}$
<b>NOISE CURRENT</b> f = 10Hz f = 1kHz f <sub>B</sub> = 0.1Hz to 10Hz			2.8 0.3 76		pA/ $\sqrt{\text{Hz}}$ pA/ $\sqrt{\text{Hz}}$ pAp-p
<b>GAIN</b> Gain Error G = 1 G = 10 G = 100 Gain vs Temperature G = 1 G = 10 G = 100 Nonlinearity G = 1 G = 10 G = 100			$\pm 0.005$ $\pm 0.02$ $\pm 0.04$  $\pm 2$ $\pm 10$ $\pm 30$  $\pm 0.001$ $\pm 0.002$ $\pm 0.004$	$\pm 0.02$ $\pm 0.05$ $\pm 0.2$      $\pm 0.003$ $\pm 0.005$ $\pm 0.01$	% % %  ppm/ $^\circ\text{C}$ ppm/ $^\circ\text{C}$ ppm/ $^\circ\text{C}$  % of FSR % of FSR % of FSR
<b>OUTPUT</b> Voltage, Positive Negative Load Capacitance, max Short-Circuit Current		(V+) -3.5 (V-) +3.5	(V+) -2.5 (V-) +2.5 1000 $\pm 25$		V V pF mA
<b>FREQUENCY RESPONSE</b> Bandwidth, -3dB G = 1 G = 10 G = 100 Slew Rate Settling Time, 0.1% G = 1 G = 10 G = 100 Settling Time, 0.01% G = 1 G = 10 G = 100 Overload Recovery	$V_O = \pm 10\text{V}$          50% Overdrive		1.5 750 250 9  2 2.2 6.5  2.5 2.5 8 2.5		MHz kHz kHz V/ $\mu\text{s}$  $\mu\text{s}$ $\mu\text{s}$ $\mu\text{s}$  $\mu\text{s}$ $\mu\text{s}$ $\mu\text{s}$ $\mu\text{s}$
<b>DIGITAL LOGIC INPUTS</b> Digital Low Voltage Digital Low or High Current Digital High Voltage		-5.6  2	  1	0.8  V+	V $\mu\text{A}$ V

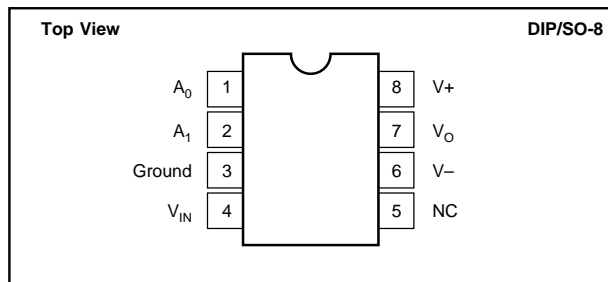
# SPECIFICATIONS (CONT)

## ELECTRICAL

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

PARAMETER	CONDITIONS	PGA103P, U			UNITS
		MIN	TYP	MAX	
<b>POWER SUPPLY</b> Voltage Range Current	$V_{IN} = 0\text{V}$	$\pm 4.5$	$\pm 15$ $\pm 2.6$	$\pm 18$ $\pm 3.5$	V mA
<b>TEMPERATURE RANGE</b> Specification Operating $\theta_{JA}$ : P or U Package		-40 -40		+85 +125	$^\circ\text{C}$ $^\circ\text{C}$ $^\circ\text{C/W}$

## PIN CONFIGURATION



## ABSOLUTE MAXIMUM RATINGS

Supply Voltage .....	$\pm 18\text{V}$
Analog Input Voltage Range .....	$V_-$ to $V_+$
Logic Input Voltage Range .....	$V_-$ to $V_+$
Output Short Circuit (to ground) .....	Continuous
Operating Temperature .....	$-40^\circ\text{C}$ to $+125^\circ\text{C}$
Storage Temperature .....	$-40^\circ\text{C}$ to $+125^\circ\text{C}$
Junction Temperature .....	$+150^\circ\text{C}$
Lead Temperature (soldering, 10s) .....	$+300^\circ\text{C}$

## PACKAGE INFORMATION

MODEL	PACKAGE	PACKAGE DRAWING NUMBER <sup>(1)</sup>
PGA103P	8-Pin Plastic DIP	006
PGA103U	SO-8 Surface-Mount	182

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

## ORDERING INFORMATION

MODEL	PACKAGE	TEMPERATURE RANGE
PGA103P	8-Pin Plastic DIP	$-40^\circ\text{C}$ to $+85^\circ\text{C}$
PGA103U	SO-8 Surface-Mount	$-40^\circ\text{C}$ to $+85^\circ\text{C}$

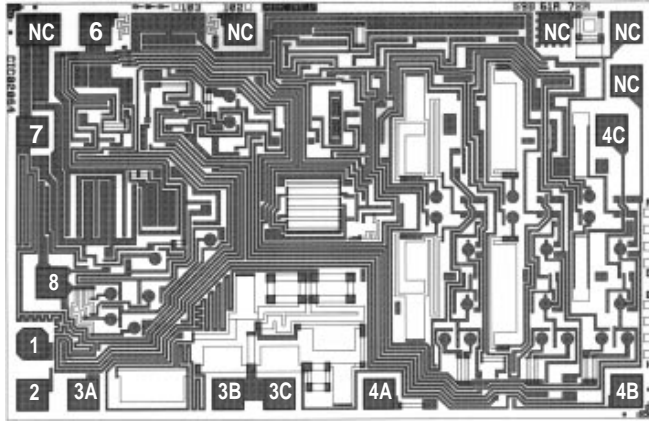
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Any integrated circuit can be damaged by ESD. Burr-Brown recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

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 published specifications.

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## DICE INFORMATION



PGA103 DIE TOPOGRAPHY

PAD	FUNCTION
1	A <sub>0</sub>
2	A <sub>1</sub>
3A, 3B, 3C <sup>(1)</sup>	Ground
4A, 4B, 4C <sup>(2)</sup>	V <sub>IN</sub>
6	V <sub>-</sub>
7	V <sub>O</sub>
8	V <sub>+</sub>

NC: No Connection

NOTES: (1) Connect all three indicated pads. (2) Connect all three indicated pads.

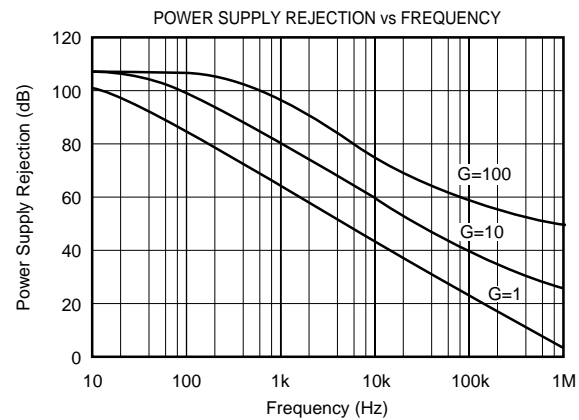
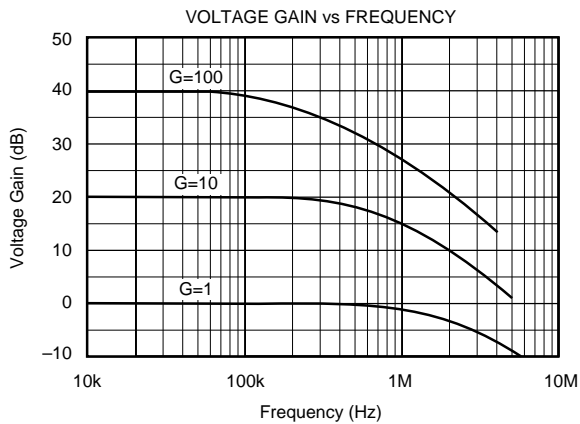
**Substrate Bias:** Internally connected to V<sub>-</sub> power supply.

## MECHANICAL INFORMATION

	MILS (0.001")	MILLIMETERS
Die Size	69 x 105 ±5	1.75 x 2.67 ±0.13
Die Thickness	20 ±3	0.51 ±0.08
Min. Pad Size	4 x 4	0.1 x 0.1
Backing	Gold	

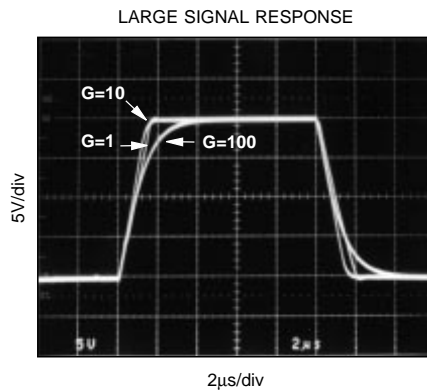
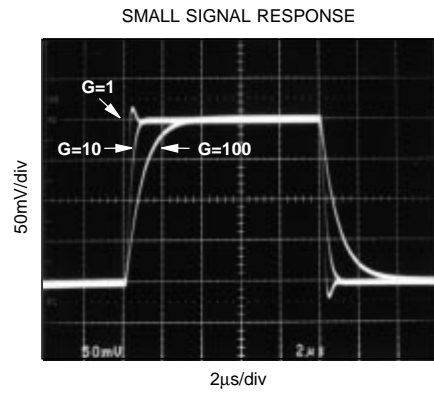
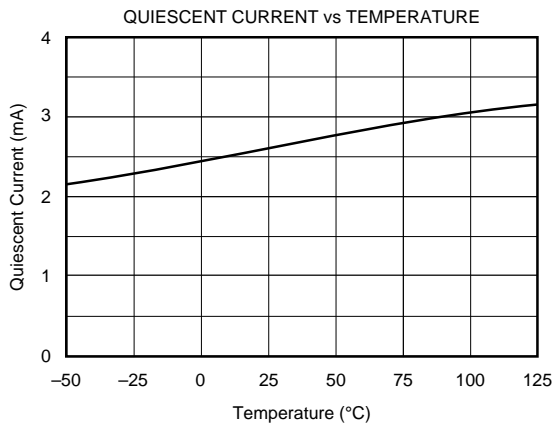
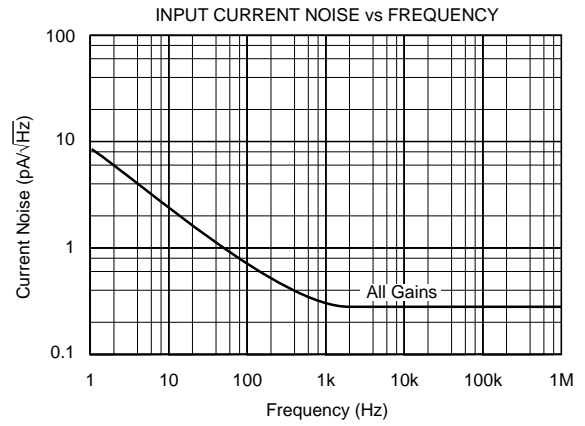
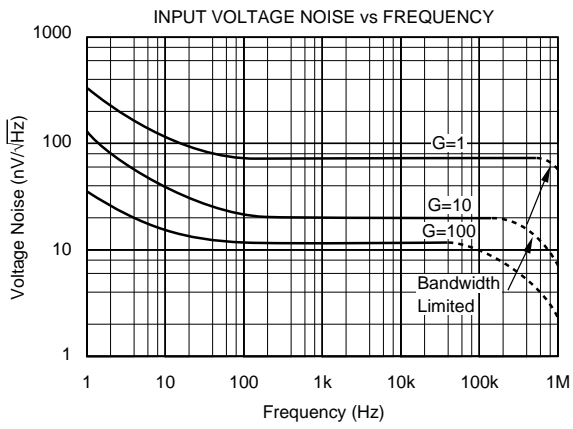
## TYPICAL PERFORMANCE CURVES

T<sub>A</sub> = +25°C, V<sub>S</sub> = ±15V unless otherwise noted.



# TYPICAL PERFORMANCE CURVES (CONT)

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



# APPLICATION INFORMATION

Figure 1 shows the basic connections required for operation of the PGA103. Applications with noisy or high impedance power supplies may require decoupling capacitors close to the device pins as shown.

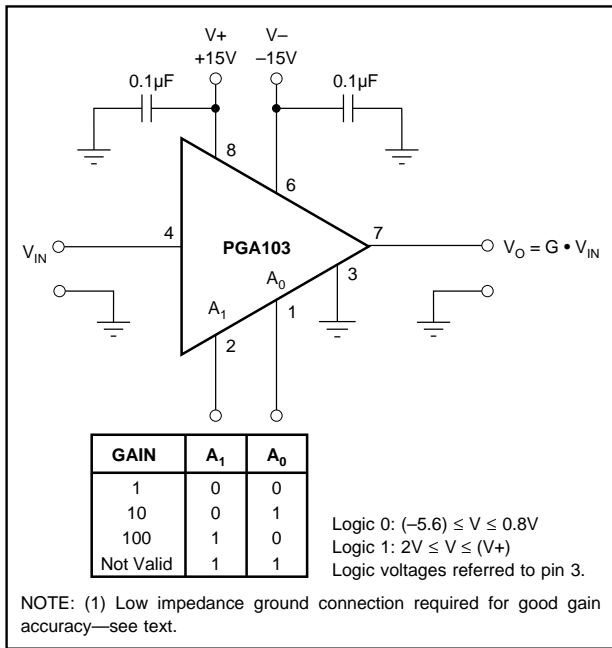


FIGURE 1. Basic Connections.

The input and output are referred to the ground terminal, pin 3. This must be a low-impedance connection to assure good gain accuracy. A resistance of  $0.1\Omega$  in series with the ground pin will cause the gain in  $G=100$  to decrease by approximately 0.2%.

## DIGITAL INPUTS

The digital inputs,  $A_0$  and  $A_1$ , select the gain according to the logic table in Figure 1. The digital inputs interface directly to common CMOS and TTL logic components. The logic inputs are referenced to the ground terminal, pin 3.

The logic table in Figure 1 shows that logic “1” on both  $A_0$  and  $A_1$  is invalid. This logic code will not cause damage, but the amplifier output will not be predictable while this code is selected. The output will recover when a valid code is selected.

The digital inputs are not latched, so a change in logic inputs immediately selects a new gain. Switching time of the logic is approximately  $0.5\mu s$ . The time to respond to gain change is equal to the switching time plus the time it takes the amplifier to settle to a new output voltage in the newly selected gain (see settling time specifications).

Many applications use an external logic latch to access gain control signals from a high speed data bus. Using an external latch isolates the high speed digital bus from sensitive analog circuitry. Locate the latch circuitry as far as practical from analog circuitry to avoid coupling digital noise into the analog circuitry.

Some applications select gain of the PGA103 with switches or jumpers. Figure 2 shows pull-up resistors connected to assure a noise-free logic “1” when the switch or jumper is off or open. Fixed-gain applications can connect the logic inputs directly to  $V+$  or ground (or other valid logic level) without a series resistor.

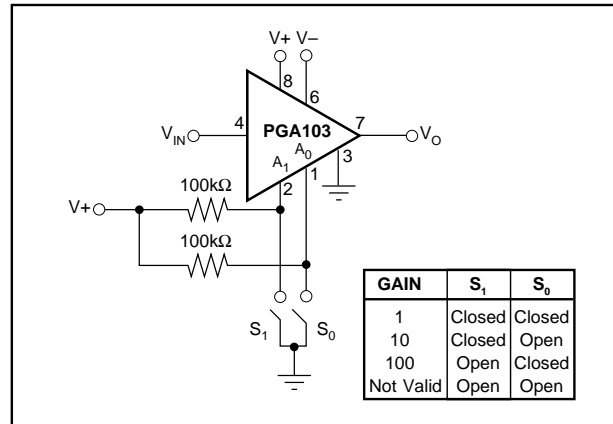


FIGURE 2. Switch or Jumper-Selected Gains.

## OFFSET TRIMMING

Offset voltage is laser-trimmed to typically less than  $200\mu V$  (referred to input) in all three gains. The input-referred offset voltage can be different for each gain.

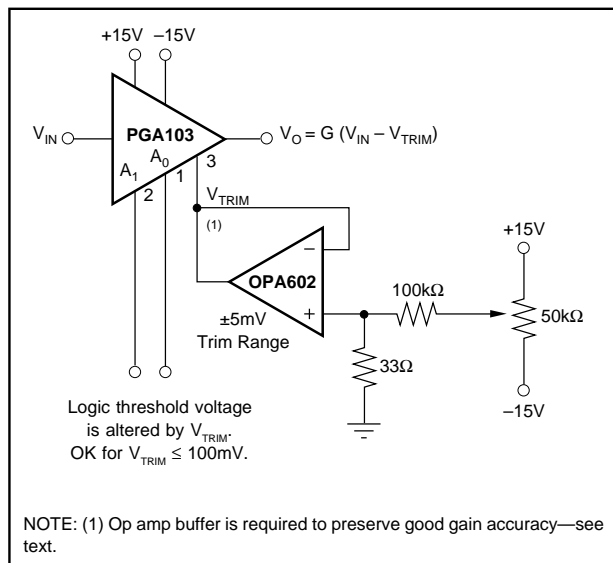


FIGURE 3. Offset Voltage Trim Circuit.

Figure 3 shows a circuit used to trim the offset voltage of the PGA103. An op amp buffers the trim voltage to provide a low impedance at the ground terminal. This is required to maintain accurate gain. Remember that the logic inputs,  $A_0$  and  $A_1$ , are referenced to this ground connection, so the logic threshold voltage will be affected by the trim voltage. This is insignificant if the offset adjustment is used only to trim offset voltage. If a large offset is used (greater than  $0.1V$ ), be sure that the logic input signals provide valid logic levels when referred to the voltage at the ground terminal, pin 3.

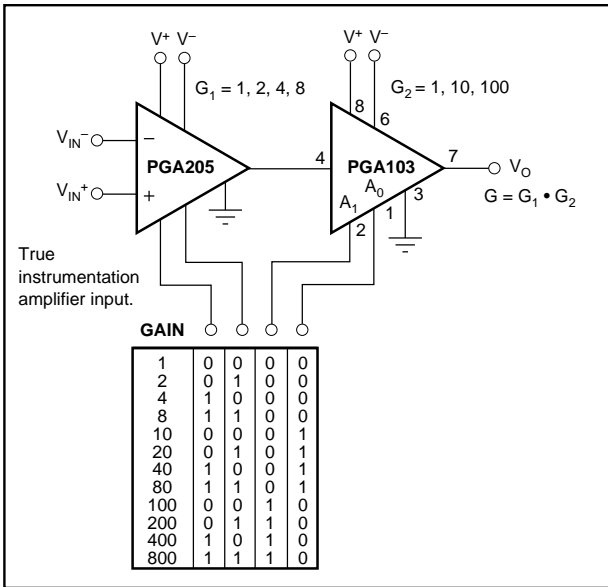


FIGURE 4. Programmable Gain Instrumentation Amplifier.

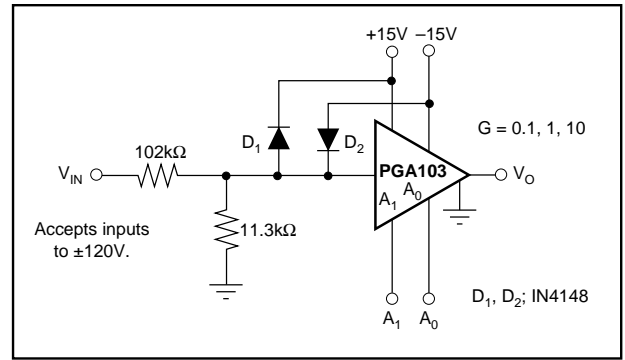


FIGURE 5. Wide Input Voltage Range Amplifier.

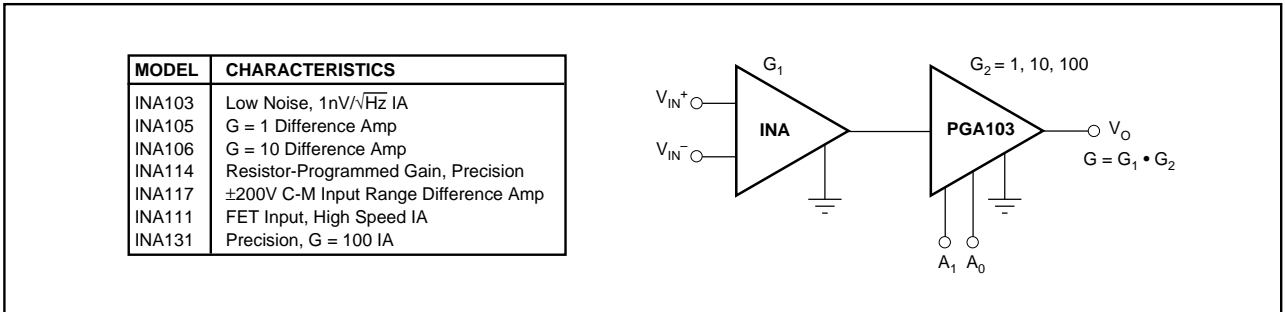


FIGURE 6. Instrumentation Amplifier with Programmable Gain Output Amp.

**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>
PGA103P	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI
PGA103U	ACTIVE	SOIC	D	8	100	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
PGA103UE4	ACTIVE	SOIC	D	8	100	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.

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