

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:  $2\mu V/^\circ C$
- LOW QUIESCENT CURRENT: 2.6mA
- LOW COST
- 8-PIN PLASTIC DIP, SO-8 PACKAGES

## APPLICATIONS

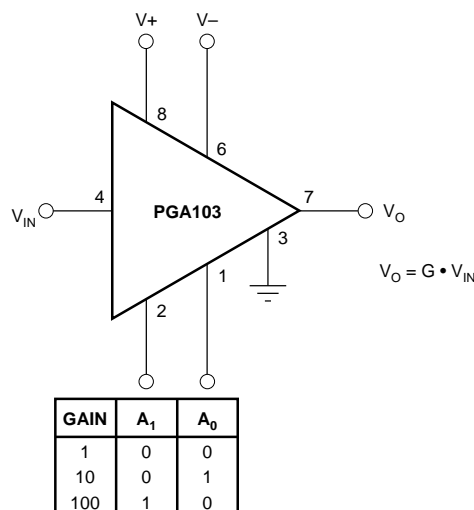
- DATA ACQUISITION SYSTEMS
- GENERAL PURPOSE ANALOG BOARDS
- MEDICAL INSTRUMENTATION

## 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 ( $8\mu s$  to 0.01%). Bandwidth is 250kHz at G=100, yet quiescent current is only 2.6mA. It operates from  $\pm 4.5V$  to  $\pm 18V$  power supplies.

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



International Airport Industrial Park • Mailing Address: PO Box 11400 • Tucson, AZ 85734 • Street Address: 6730 S. Tucson Blvd. • Tucson, AZ 85706  
 Tel: (520) 746-1111 • Twx: 910-952-1111 • Cable: BBRCORP • Telex: 066-6491 • FAX: (520) 889-1510 • Immediate Product Info: (800) 548-6132

# 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

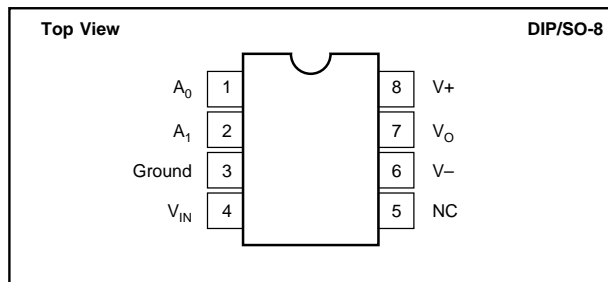
# SPECIFICATIONS (CONT)

## 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	100	+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 $+85^\circ\text{C}$

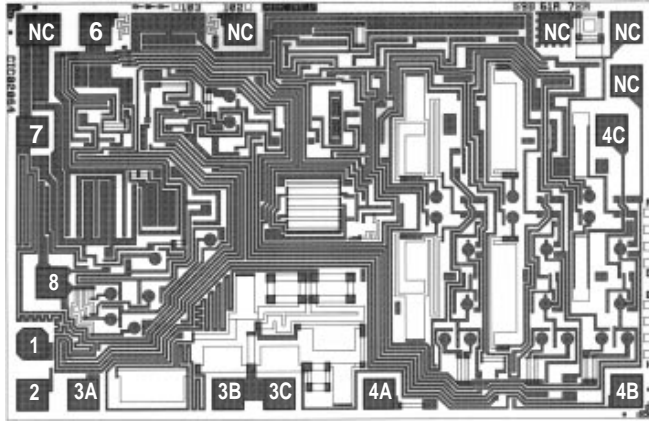
## ELECTROSTATIC DISCHARGE SENSITIVITY

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.

The information provided herein is believed to be reliable; however, BURR-BROWN assumes no responsibility for inaccuracies or omissions. BURR-BROWN assumes no responsibility for the use of this information, and all use of such information shall be entirely at the user's own risk. Prices and specifications are subject to change without notice. No patent rights or licenses to any of the circuits described herein are implied or granted to any third party. BURR-BROWN does not authorize or warrant any BURR-BROWN product for use in life support devices and/or systems.

## 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.

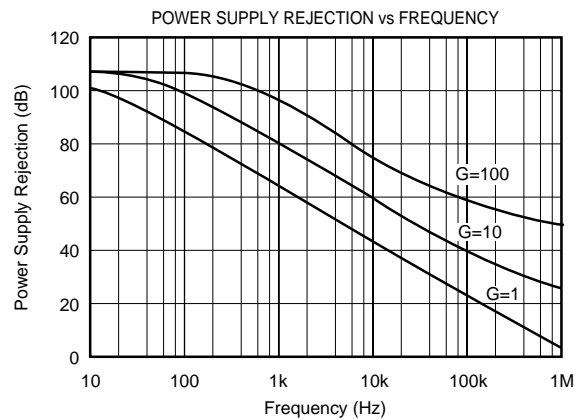
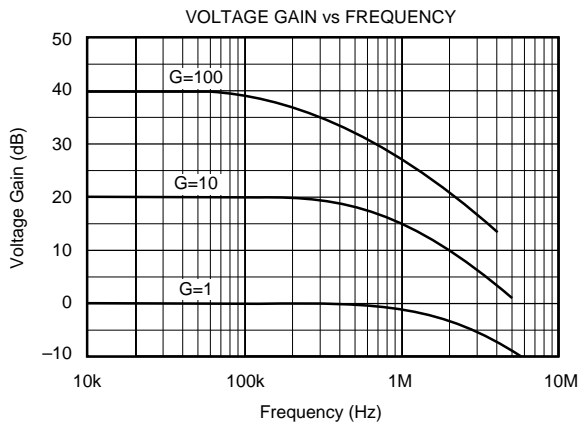
**Substrate Bias:** Internally connected to V<sub>-</sub> power supply.

## 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

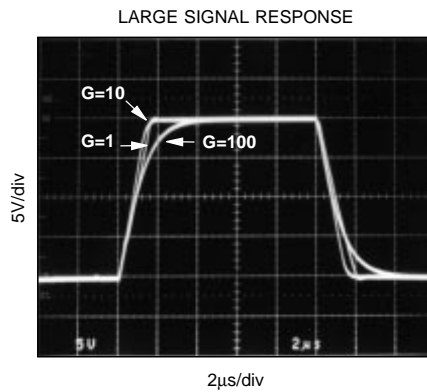
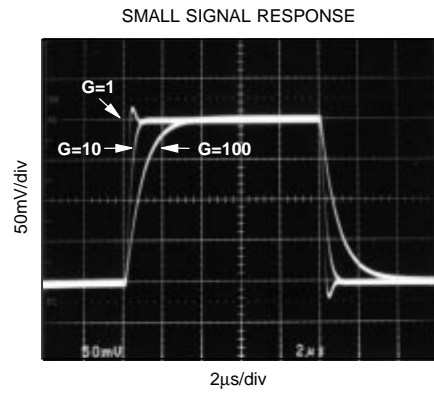
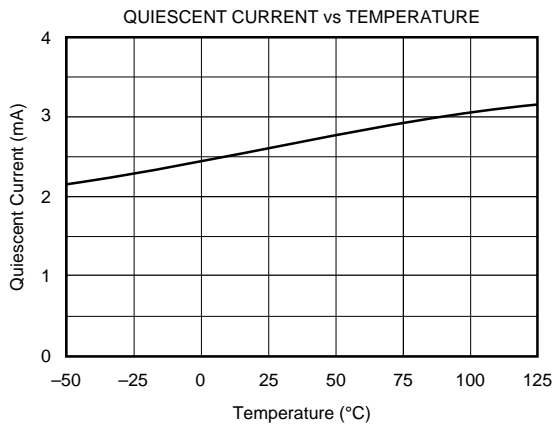
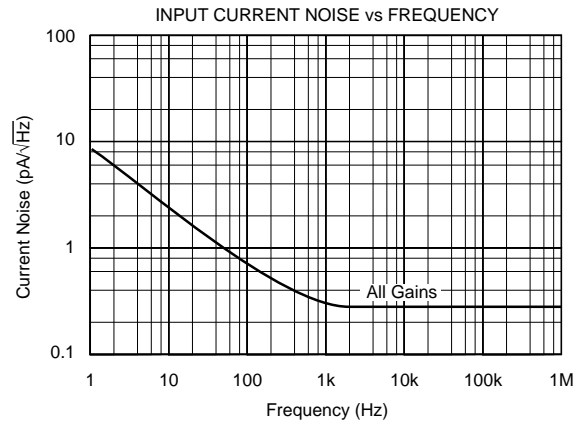
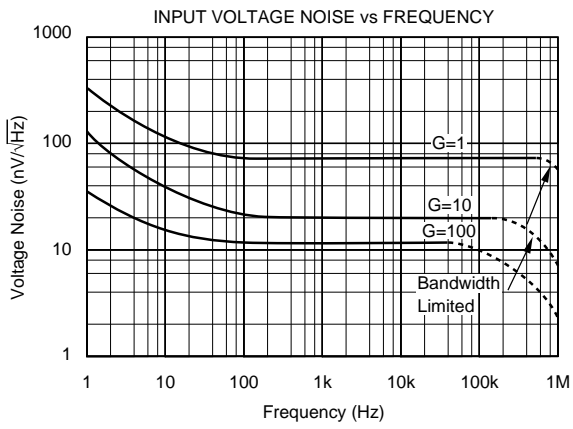
## TYPICAL PERFORMANCE CURVES

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.

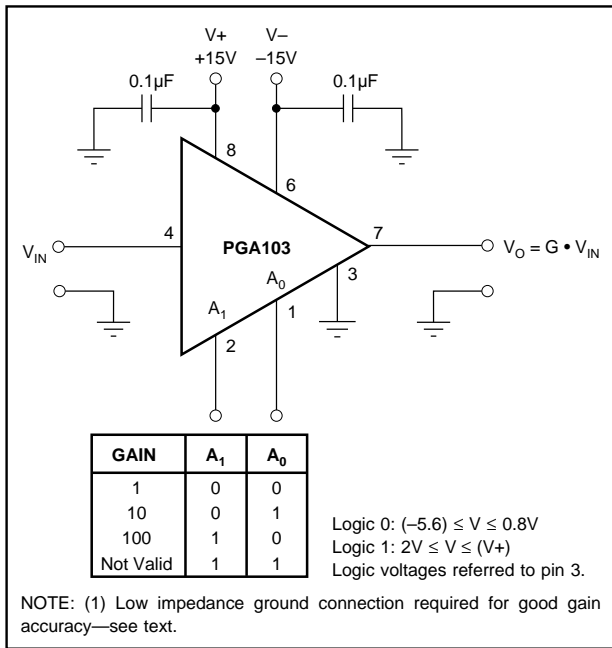


FIGURE 1. Basic Connections.

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.

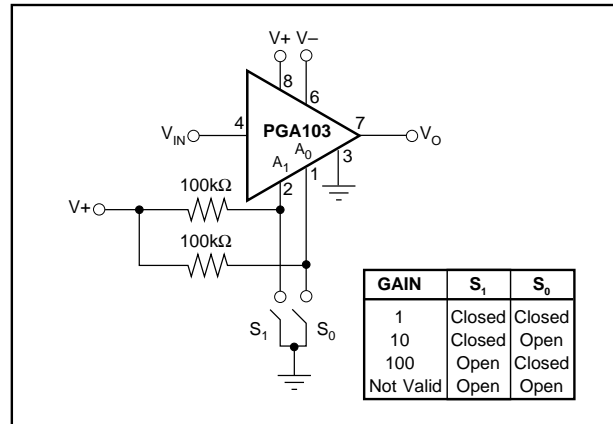


FIGURE 2. Switch or Jumper-Selected Gains.

## 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.

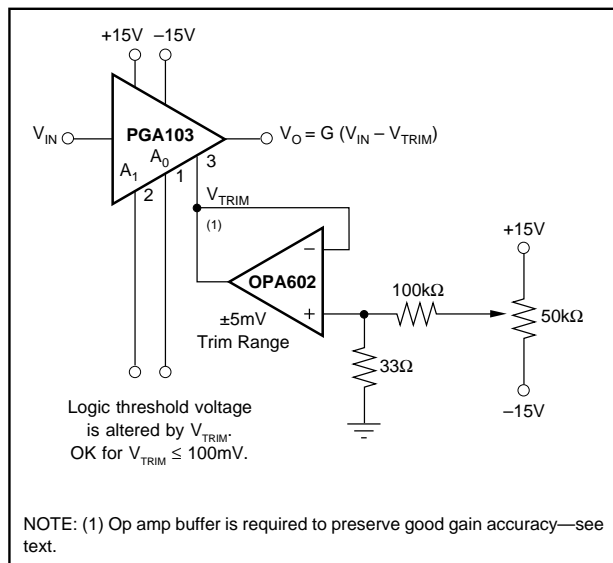


FIGURE 3. Offset Voltage Trim Circuit.

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.

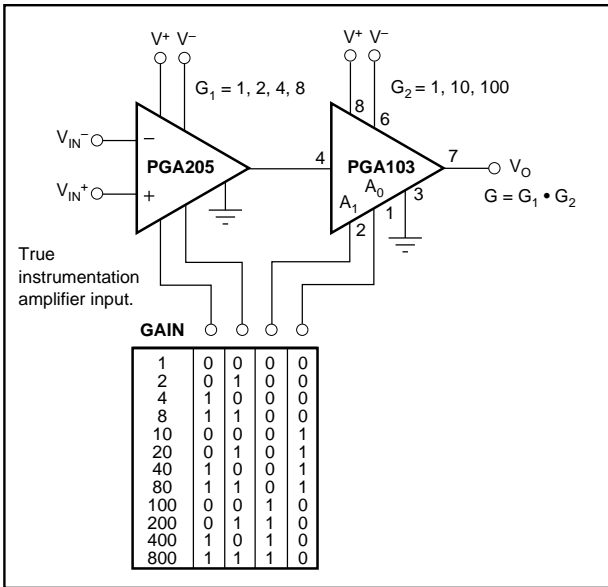


FIGURE 4. Programmable Gain Instrumentation Amplifier.

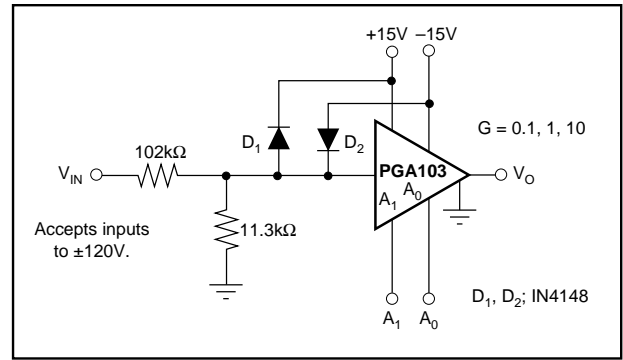


FIGURE 5. Wide Input Voltage Range Amplifier.

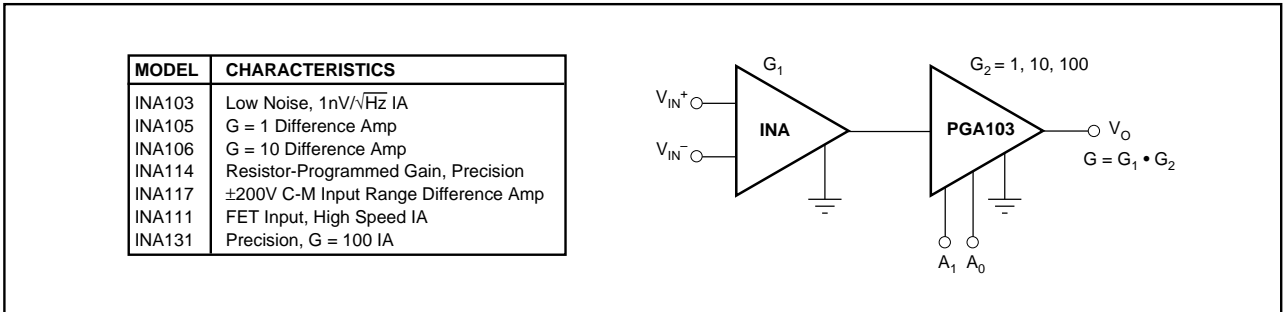


FIGURE 6. Instrumentation Amplifier with Programmable Gain Output Amp.

**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	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
PGA103UE4	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.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

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

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

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI 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 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. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

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>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>

### Applications

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
Video & Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
Wireless	<a href="http://www.ti.com/wireless">www.ti.com/wireless</a>

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2009, Texas Instruments Incorporated