



PGA102

## High Speed PROGRAMMABLE GAIN AMPLIFIER

### FEATURES

- DIGITALLY PROGRAMMABLE GAIN:  
G = 1, 10, 100
- LOW GAIN ERROR: 0.025% max
- FAST SETTLING: 2.8 $\mu$ s to 0.01%
- 16-PIN PLASTIC AND CERAMIC DIP

### APPLICATIONS

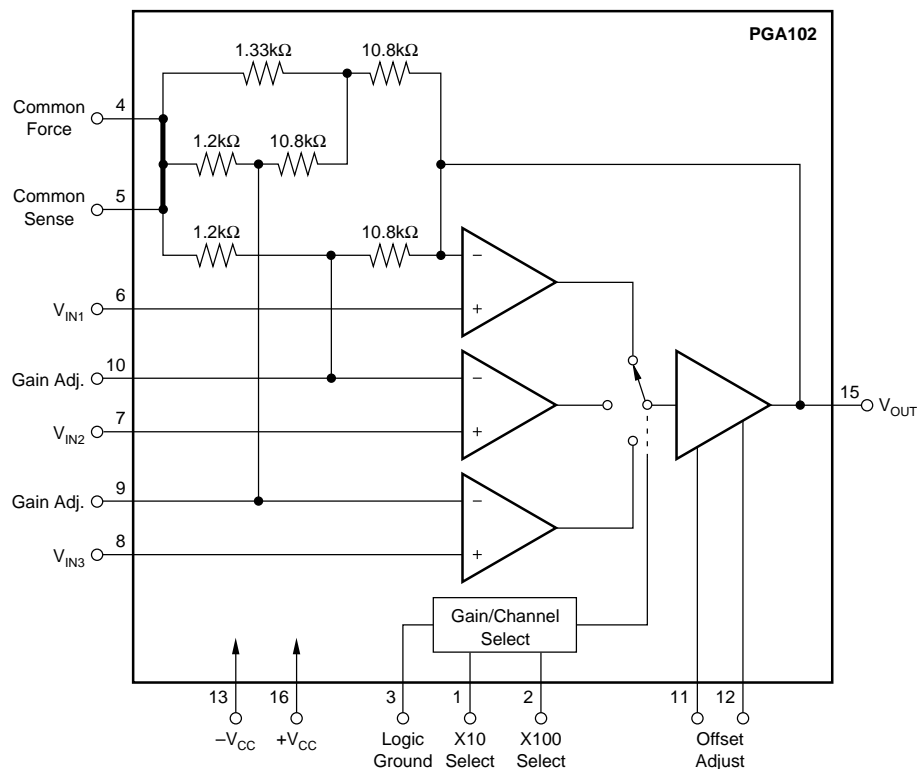
- DATA ACQUISITION AMPLIFIER
- FIXED-GAIN AMPLIFIER
- AUTOMATIC GAIN SCALING

### DESCRIPTION

The PGA102 is a high speed, digitally programmable-gain amplifier. CMOS/TTL-compatible inputs select gains of 1, 10 or 100V/V. Each gain has an independent input terminal, providing an input multiplexer function.

On-chip metal film gain-set resistors are laser-trimmed to provide excellent gain accuracy. High speed input circuitry allows multiplexing of high speed signals.

The PGA102 is available in 16-pin plastic and ceramic DIP packages. Commercial, industrial and military temperature range models are available.



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# SPECIFICATIONS

## ELECTRICAL

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

| PARAMETER  | CONDITIONS                                    | PGA102AG             |                 |       | PGA102BG, SG |        |        | PGA102KP |     |        | UNITS   |    |
|--|---|----------------------|-----------------|-------|--------------|--------|--------|----------|-----|--------|---------|----|
|  |   | MIN                  | TYP             | MAX   | MIN          | TYP    | MAX    | MIN      | TYP | MAX    |         |    |
| <b>GAIN</b><br>Inaccuracy <sup>(1)</sup><br><br>vs Temperature<br><br>Nonlinearity                             | $R_L = 2k\Omega$ , $G = 1$                    |                      | ±0.007          | ±0.02 |              | ±0.003 | ±0.01  |          | *   | *      | %       |    |
|  | $G = 10$                                      |                      | ±0.015          | ±0.03 |              | ±0.01  | ±0.02  |          | *   | ±0.05  | %       |    |
|  | $G = 100$                                     |                      | ±0.02           | ±0.05 |              | ±0.015 | ±0.025 |          | *   | ±0.06  | %       |    |
|  | $G = 1$                                       |                      | ±0.4            | ±5    |              | *      | *      |          | *   | *      | ppm/°C  |    |
|  | $G = 10$                                      |                      | ±2              | ±7    |              | *      | *      |          | *   | *      | ppm/°C  |    |
|  | $G = 100$                                     |                      | ±7              | ±20   |              | *      | *      |          | ±9  | *      | ppm/°C  |    |
|  | $R_L = 2k\Omega$ , $G = 1$                    |                      | 0.001           | 0.003 |              | *      | *      |          | *   | *      | % of FS |    |
|  | $G = 10$                                      |                      | 0.002           | 0.005 |              | *      | *      |          | *   | *      | % of FS |    |
|  | $G = 100$                                     |                      | 0.003           | 0.01  |              | *      | *      |          | *   | *      | % of FS |    |
| <b>RATED OUTPUT</b><br>Voltage<br>Current<br>Short Circuit Current<br>Output Resistance<br>Load Capacitance    | $R_L = 2k\Omega$                              | ±10                  | ±12.5           |       | *            | *      |        | *        | *   |        | V       |    |
|  | $V_{OUT} = 10V$                               | ±5                   | ±10             |       | *            | *      |        | *        | *   |        | mA      |    |
|  |   | ±10                  | ±25             |       | *            | *      |        | *        | *   |        | mA      |    |
|  |   |                      | 0.01            |       |              | *      |        |          | *   |        | Ω       |    |
|  |   | For Stable Operation |                 | 2000  |              | *      |        |          | *   |        |         | pF |
|  |   |                      |                 |       |              |        |        |          |     |        |         |    |
| <b>INPUT OFFSET VOLTAGE</b><br>Initial <sup>(2)</sup><br><br>vs Temperature<br><br>vs Supply Voltage           | $G = 1$                                       |                      | ±200            | ±500  |              | ±100   | ±250   |          | *   | ±1500  | μV      |    |
|  | $G = 10$                                      |                      | ±70             | ±200  |              | ±50    | ±100   |          | *   | ±600   | μV      |    |
|  | $G = 100$                                     |                      | ±70             | ±200  |              | ±50    | ±100   |          | *   | ±600   | μV      |    |
|  | $G = 1$                                       |                      | ±5              | ±20   |              | *      | *      |          | ±7  | ±50    | μV/°C   |    |
|  | $G = 10$                                      |                      | ±1              | ±7    |              | *      | *      |          | ±3  | ±10    | μV/°C   |    |
|  | $G = 100$                                     |                      | ±0.5            | ±3    |              | *      | *      |          | ±2  | ±7     | μV/°C   |    |
|  | $\pm 5 < V_{CC} < \pm 18V$                    |                      |                 |       |              |        |        |          |     |        |         |    |
|  | $G = 1$                                       |                      | ±30             | ±70   |              | *      | *      |          | *   | *      | μV/V    |    |
|  | $G = 10$                                      |                      | ±8              | ±30   |              | *      | *      |          | *   | *      | μV/V    |    |
|  | $G = 100$                                     |                      | ±8              | ±30   |              | *      | *      |          | *   | *      | μV/V    |    |
| <b>INPUT BIAS CURRENT</b><br>Initial<br>Over Temperature   | $T_A = +25^\circ C$                           |                      | ±20             | ±50   |              | *      | *      |          | *   | *      | nA      |    |
|  | $T_{A \text{ MIN}}$ to $T_{A \text{ MAX}}$    |                      | ±25             | ±60   |              | *      | *      |          | *   | *      | nA      |    |
| <b>ANALOG INPUT CHARACTERISTICS</b><br>Voltage Range<br>Resistance<br>Capacitance                              | Linear Operation                              | ±10                  | ±12             |       | *            | *      |        | *        | *   |        | V       |    |
|  |   |                      | $7 \times 10^8$ |       |              | *      |        |          | *   |        | Ω       |    |
|  |   |                      | 4               |       |              | *      |        |          | *   |        | pF      |    |
| <b>INPUT NOISE</b><br>Voltage Noise<br><br>Voltage Noise Density<br><br>Current Noise<br>Current Noise Density | $f_B = 0.1Hz$ to 10Hz<br>$G = 1$              |                      | 4.5             |       |              | *      |        |          | *   |        | μVp-p   |    |
|  | $G = 10$                                      |                      | 1.5             |       |              | *      |        |          | *   |        | μVp-p   |    |
|  | $G = 100$                                     |                      | 0.6             |       |              | *      |        |          | *   |        | μVp-p   |    |
|  | $f_O = 1Hz$ , $G = 1$                         |                      | 490             |       |              | *      |        |          | *   |        | nV/√Hz  |    |
|  | $G = 10$                                      |                      | 178             |       |              | *      |        |          | *   |        | nV/√Hz  |    |
|  | $G = 100$                                     |                      | 83              |       |              | *      |        |          | *   |        | nV/√Hz  |    |
|  | $f_O = 10Hz$ , $G = 1$                        |                      | 155             |       |              | *      |        |          | *   |        | nV/√Hz  |    |
|  | $G = 10$                                      |                      | 56              |       |              | *      |        |          | *   |        | nV/√Hz  |    |
|  | $G = 100$                                     |                      | 20              |       |              | *      |        |          | *   |        | nV/√Hz  |    |
|  | $f_O = 100Hz$ , $G = 1$                       |                      | 93              |       |              | *      |        |          | *   |        | nV/√Hz  |    |
|  | $G = 100$                                     |                      | 31              |       |              | *      |        |          | *   |        | nV/√Hz  |    |
|  | $G = 100$                                     |                      | 18              |       |              | *      |        |          | *   |        | nV/√Hz  |    |
|  | $f_O = 1kHz$ , $G = 1$                        |                      | 79              |       |              | *      |        |          | *   |        | nV/√Hz  |    |
|  | $G = 10$                                      |                      | 31              |       |              | *      |        |          | *   |        | nV/√Hz  |    |
|  | $G = 100$                                     |                      | 18              |       |              | *      |        |          | *   |        | nV/√Hz  |    |
|  | $f_B = 0.1Hz$ to 10Hz                         |                      | 76              |       |              | *      |        |          | *   |        | pAp-p   |    |
|  | $f_O = 1Hz$                                   |                      | 8.8             |       |              | *      |        |          | *   |        | pA/√Hz  |    |
|  | $f_O = 10Hz$                                  |                      | 2.8             |       |              | *      |        |          | *   |        | pA/√Hz  |    |
| $f_O = 100Hz$  |   | 0.99                 |                 |       | *            |        |        | *        |     | pA/√Hz |         |    |
| $f_O = 1kHz$   |   | 0.43                 |                 |       | *            |        |        | *        |     | pA/√Hz |         |    |
| <b>DYNAMIC RESPONSE</b><br>±3dB Bandwidth<br><br>Full Power Bandwidth<br>Slew Rate                             | Small Signal, $G = 1$                         |                      | 1500            |       |              | *      |        |          | *   |        | kHz     |    |
|  | $G = 10$                                      |                      | 750             |       |              | *      |        |          | *   |        | kHz     |    |
|  | $G = 100$                                     |                      | 250             |       |              | *      |        |          | *   |        | kHz     |    |
|  | $V_{OUT} = \pm 10V$ , $R_L = 2k\Omega$        |                      | 160             |       |              | *      |        |          | *   |        | kHz     |    |
|  | $V_{OUT} = \pm 10V$ Step,<br>$R_L = 2k\Omega$ | 6                    | 9               |       | *            | *      |        | *        | *   |        | V/μs    |    |

# SPECIFICATIONS (CONT)

## ELECTRICAL

At +25°C,  $\pm V_{CC} = 15\text{VDC}$  unless otherwise specified.

| PARAMETER                            | CONDITIONS   | PGA102AG  |                   |              | PGA102BG |     |      | PGA102KP |     |     | UNITS   |                      |
|--------------------------------------|--|-----------|-------------------|--------------|----------|-----|------|----------|-----|-----|---|----------------------|
|                                      |  | MIN       | TYP               | MAX          | MIN      | TYP | MAX  | MIN      | TYP | MAX |   |                      |
| <b>DYNAMIC RESPONSE (CONT)</b>       |  |           |                   |              |          |     |      |          |     |     |   |                      |
| Settling Time (0.1%)                 | $V_{OUT} = 10\text{V Step}$ , $G = 1$<br>$G = 10$<br>$G = 100$           |           | 1.6<br>2.2<br>5.2 |              |          | *   |      |          | *   |     | $\mu\text{s}$<br>$\mu\text{s}$<br>$\mu\text{s}$ |                      |
| Settling Time (0.01%)                | $V_{OUT} = 10\text{V Step}$ , $G = 1$<br>$G = 10$<br>$G = 100$           |           | 2.8<br>2.8<br>8.2 |              |          | *   |      |          | *   |     | $\mu\text{s}$<br>$\mu\text{s}$<br>$\mu\text{s}$ |                      |
| Overload Recovery Time, 0.1%         | 50% Overdrive, $G = 1$<br>(see Performance Curve)                        |           | 2.5               |              |          | *   |      |          | *   |     | $\mu\text{s}$                                   |                      |
| <b>CROSSTALK</b>                     |  |           |                   |              |          |     |      |          |     |     |   |                      |
| DC                                   | $\pm 10\text{V}$ to Both Off Channels                                    |           | -155              |              |          | *   |      |          | *   |     | dB  |                      |
| 60Hz                                 | $\pm 10\text{V}$ to Both Off Channels                                    |           | -144              |              |          | *   |      |          | *   |     | dB  |                      |
| <b>DIGITAL INPUT CHARACTERISTICS</b> |  |           |                   |              |          |     |      |          |     |     |   |                      |
| Input "Low" Threshold                | $V_{IL}^{(3)}$ on Pin 1 or 2   |           |                   | VLTC+0.8     |          |     |      |          |     | *   | V   |                      |
| Input "Low" Current                  |  |           |                   | 1            |          |     |      |          |     | *   | $\mu\text{A}$                                   |                      |
| Input "High" Threshold               | $V_{IH}^{(3)}$ on Pin 1 or 2   | VLTC+2    |                   | 1            | *        |     | *    | *        |     | *   | V   |                      |
| Input "High" Current                 |  |           | 0.1               | 1            |          | *   | *    | *        |     | *   | $\mu\text{A}$                                   |                      |
| Logic Threshold Control              | VLTC on Pin 3  | $-V_{CC}$ |                   | $V_{CC} - 4$ | *        |     | *    | *        |     | *   | V   |                      |
| Switching Time <sup>(4)</sup>        | Between Channels   |           | 1                 |              |          | *   |      | *        |     | *   | $\mu\text{s}$                                   |                      |
| <b>POWER SUPPLY</b>                  |  |           |                   |              |          |     |      |          |     |     |   |                      |
| Rated Voltage                        |  |           | $\pm 15$          |              |          | *   |      | *        | *   | *   | VDC   |                      |
| Voltage Range                        |  | $\pm 5$   |                   | $\pm 18$     |          |     | *    | *        | *   | *   | VDC   |                      |
| Quiescent Current                    | $V_{OUT} = 0\text{V}$<br>No External Load,<br>$V_{OUT} = \pm 10\text{V}$ |           | $\pm 2.4$         | $\pm 3.3$    |          |     | *    | *        | *   | *   | mA  |                      |
|                                      |  |           |                   | $\pm 5.3$    |          |     |      | *        | *   | *   | mA  |                      |
| <b>TEMPERATURE RANGE</b>             |  |           |                   |              |          |     |      |          |     |     |   |                      |
| Specification, KP Grade              | $T_{A \text{ MIN}}$ to $T_{A \text{ MAX}}$                               |           |                   |              |          |     |      | 0        |     |     | +70   | $^{\circ}\text{C}$   |
| AG and BG Grades                     |  | -25       |                   | +85          | *        |     | *    |          |     |     |   | $^{\circ}\text{C}$   |
| SG Grade                             |  |           |                   |              | -55      |     | +125 |          |     |     |   | $^{\circ}\text{C}$   |
| Operating                            |  | -55       |                   | +125         | *        |     | *    | -25      |     |     | +85   | $^{\circ}\text{C}$   |
| Storage                              |  | -65       |                   | +150         | *        |     | *    | -55      |     |     | +125  | $^{\circ}\text{C}$   |
| Thermal Resistance                   | $\theta_{JA}$  |           | 100               |              |          | *   | *    |          | *   |     |   | $^{\circ}\text{C/W}$ |

\* Specification same as AG grade.

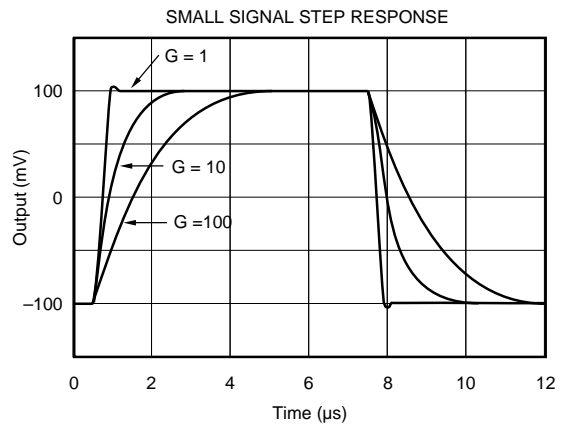
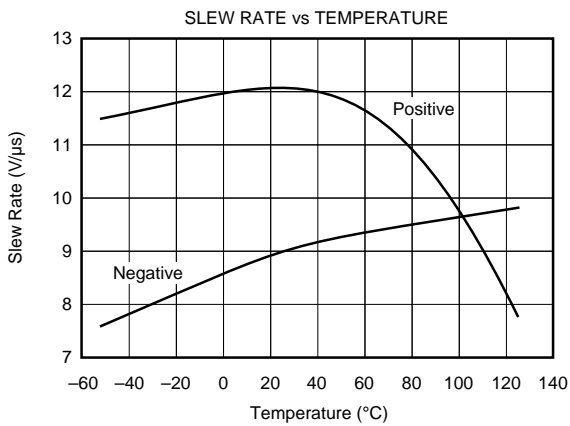
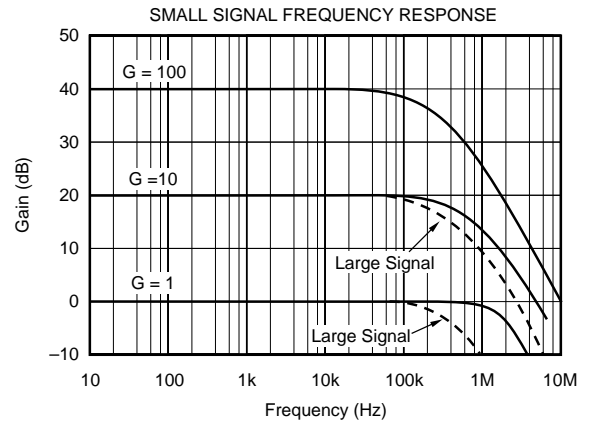
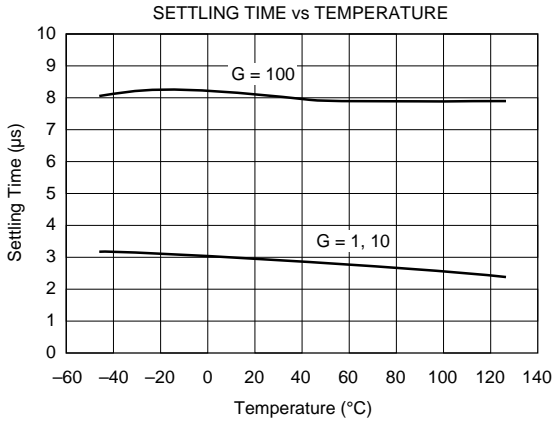
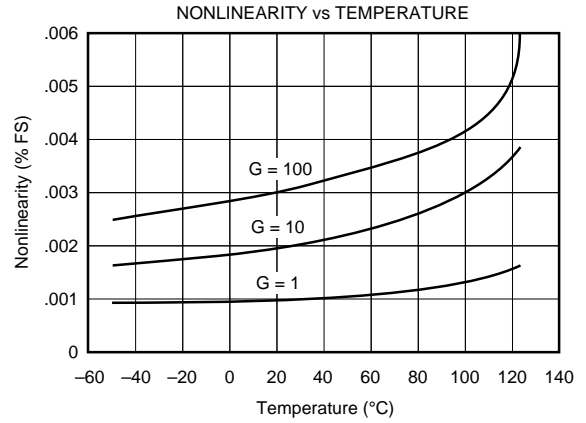
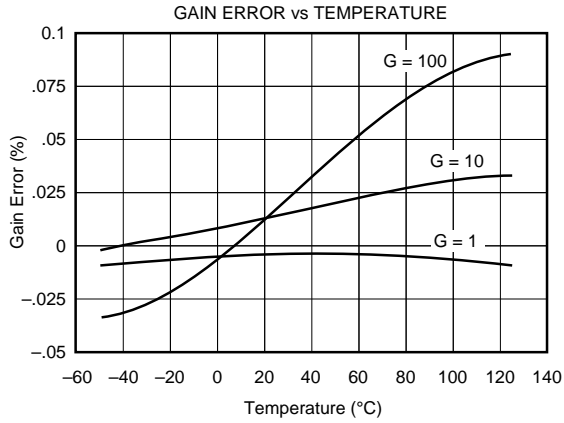
NOTES: (1) Gain inaccuracy is the percent error between the actual and ideal gain selected. It may be externally adjusted to zero for gains of 10 and 100. (2) Offset voltage can be adjusted for any one channel. Adjustment affects temperature drift by approximately  $\pm 0.3\mu\text{V}/^{\circ}\text{C}$  for each  $100\mu\text{V}$  of offset adjusted. (3) Voltage on the logic threshold control pin, VLTC, adjusts the threshold for "Low" and "High" logic levels. (4) Total time to settle equals switching time plus settling time of the newly selected gain.

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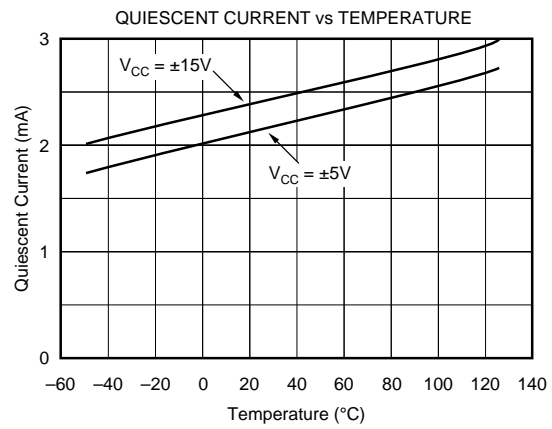
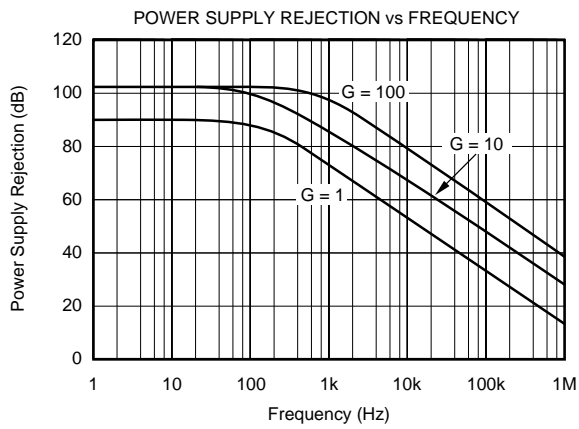
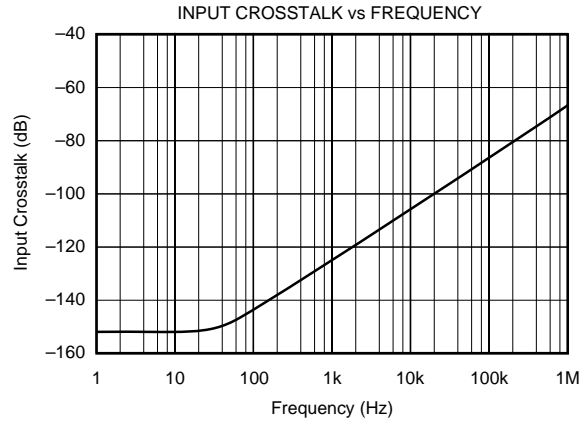
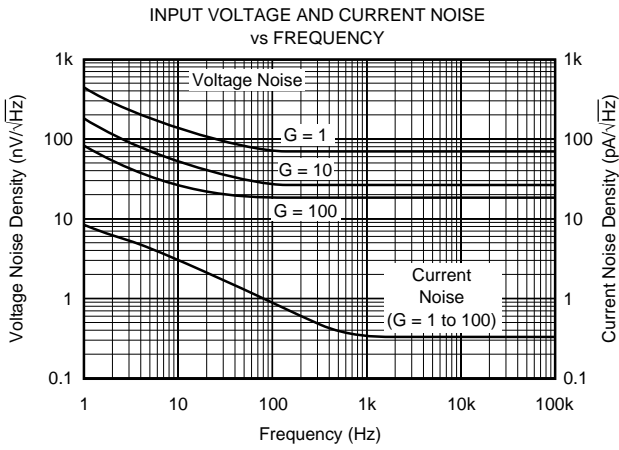
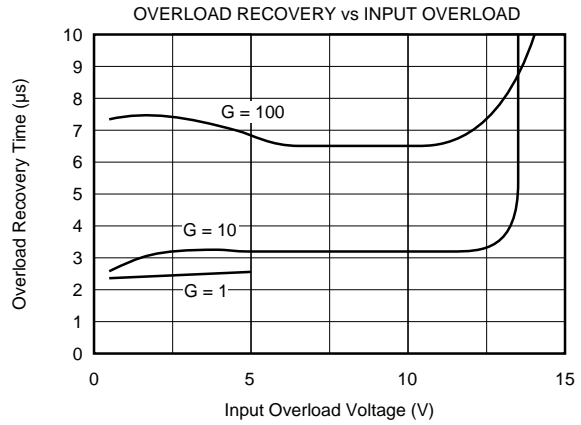
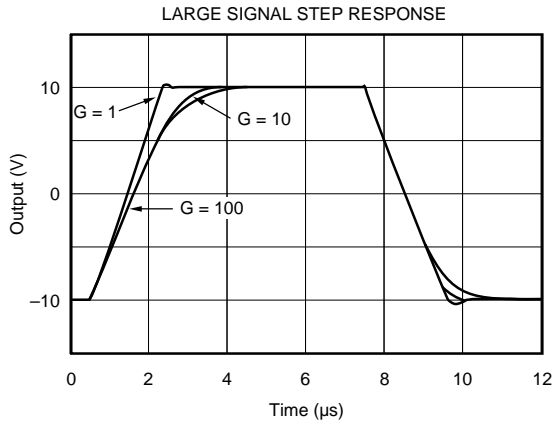
# TYPICAL PERFORMANCE CURVES

$T_A = +25^\circ\text{C}$ ,  $\pm V_{CC} = 15\text{VDC}$  unless otherwise noted.



# TYPICAL PERFORMANCE CURVES (CONT)

$T_A = +25^\circ\text{C}$ ,  $\pm V_{CC} = 15\text{VDC}$  unless otherwise noted.



## APPLICATION INFORMATION

Figure 1 shows the basic connections required for operation of the PGA102. Power supplies should be bypassed with 0.1μF capacitors located close to the device pins.

The inputs for each gain are independent and can be connected to three separate signal sources. Or, for many applications, the three inputs are connected in parallel to form a single input—see Figure 1. Only the input corresponding to the selected gain is active, operating as a non-inverting amplifier. The two inactive inputs behave as open circuits. The input bias current of the inactive inputs is negligible compared to that of the selected input.

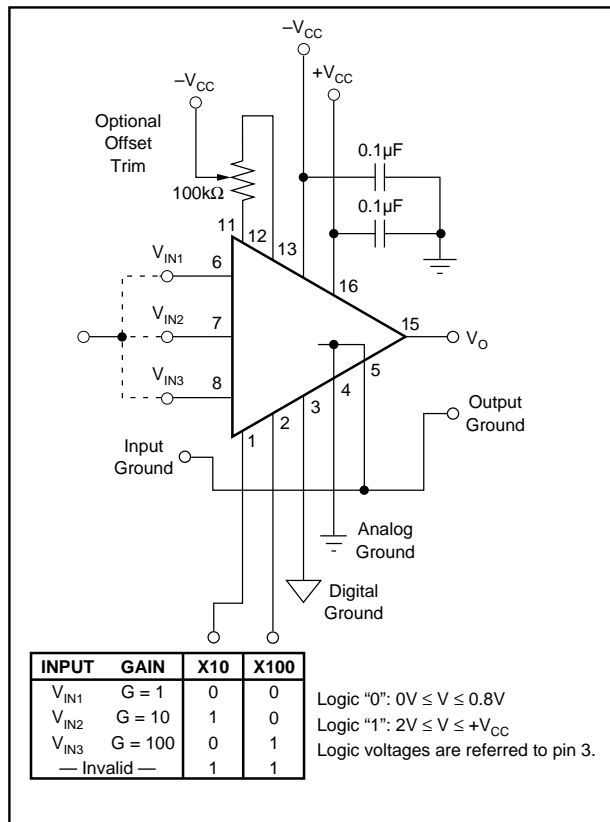


FIGURE 1. Basic Circuit Connections.

### DIGITAL INPUTS

Gain is selected by the digital input pins, "X10" and "X100". The threshold of these logic inputs is approximately 1.3V above the voltage on pin 3. For CMOS or TTL logic signals, connect pin 3 to logic ground. The logic inputs are not latched. Any change logic inputs immediately selects a new gain. Switching time is approximately 1μs. This does not include the time required for the analog output to settle to a new output value (see settling time specifications).

Note that the two logic inputs allow four possible logic states—see Figure 1 for the logic table. A logic "1" on both inputs is an invalid code. This will not damage the device, but the analog output voltage will not be predictable while this code is applied.

### OFFSET ADJUSTMENT

The offset voltage of each of the three input stages is laser-trimmed. Many applications require no further adjustment. The optional trim circuit shown in Figure 1 can be used to adjust the offset voltage. This adjustment affects the offset of all three gain channels. Since each gain setting may require a different adjustment of the potentiometer, this requires a compromise. Often, offset voltage of the  $G = 100$  channel is the most important, so adjustment can be optimized for this channel only. Alternatively, Figure 2 shows a CMOS switch used to select independent offset adjustment potentiometers for each of the three channels.

Use these offset adjustment techniques only to null the offset voltage of the PGA102. Do not null offset produced by the signal source or other system offsets or this will increase the temperature drift of the PGA102.

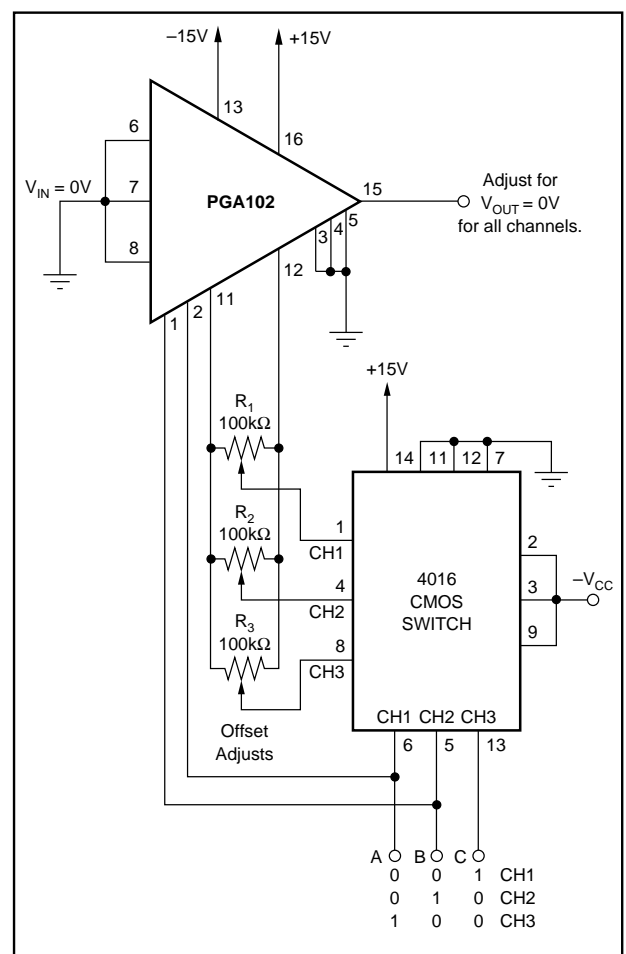


FIGURE 2. Independent Offset Adjustment of Channels 1, 2, and 3.

### GAIN ADJUSTMENT

Gain of the PGA102 is accurately laser trimmed and usually requires no further adjustment. The optional circuit in Figure 3 allows independent gain adjustment of the  $G = 10$  and  $G = 100$  inputs.

The gain of the G = 10 and G = 100 inputs can be changed by adding external resistors to the internal feedback network as shown in Figures 4 and 5. The internal gain-set resistors are trimmed for precise ratios, not to exact values. The internal resistor values are within approximately ±30% of

the nominal values shown on the front page diagram. This makes the external resistor values in Figures 4 and 5 subject to variation—especially for gains differing greatly from the initial value.

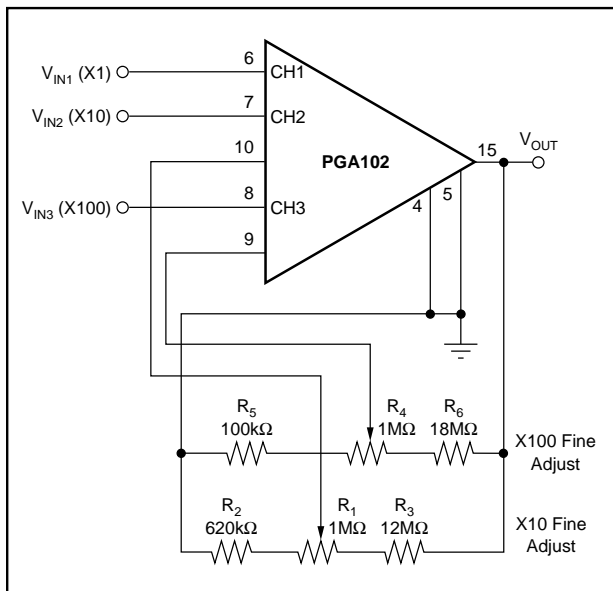


FIGURE 3. Optional Fine Gain Adjustment.

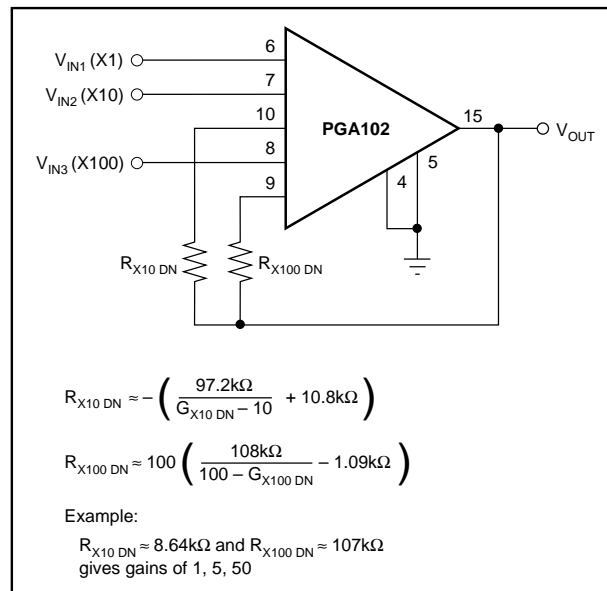


FIGURE 5. Connections for Lower Gains.

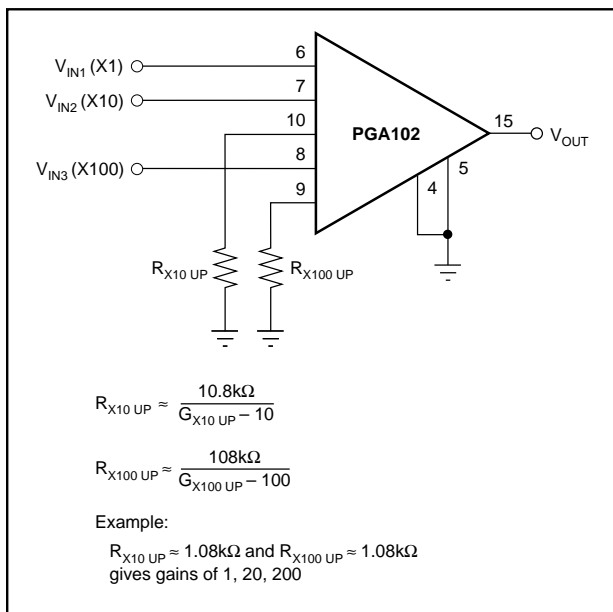


FIGURE 4. Connections for Higher Gains.

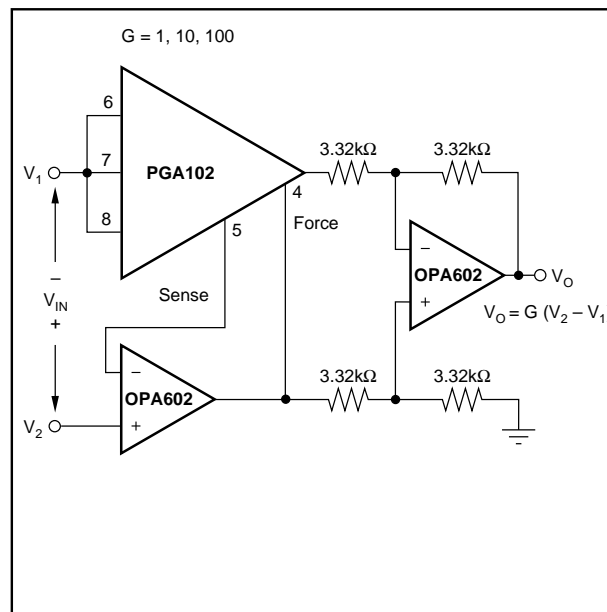


FIGURE 6. High-Speed Instrumentation Amplifier.



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