

## High Temperature 175°C Dual 100MHz, Rail-to-Rail Input and Output, Ultralow 1.9nV/√Hz Noise, Low Power Op Amp

### FEATURES

- **Extreme High Temperature Operation: -40°C to 175°C**
- **Low Noise Voltage: 1.9nV/√Hz (100kHz)**
- **Low Supply Current: 3mA/Amp Max**
- **Gain Bandwidth Product: 100MHz**
- Low Distortion: -80dB at 1MHz
- Low Offset Voltage: 500μV Max
- Wide Supply Range: 2.5V to 12.6V
- Inputs and Outputs Swing Rail-to-Rail
- Common Mode Rejection Ratio 90dB Typ
- Low Noise Current: 1.1pA/√Hz
- Output Current: 30mA Min
- 8-Pin SO Package
- Available as Dice

### APPLICATIONS

- Down Hole Drilling and Instrumentation
- Heavy Industrial
- Avionics
- High Temperature Environments
- Low Noise, Low Power Signal Processing
- Active Filters
- Rail-to-Rail Buffer Amplifiers
- Driving A/D Converters
- DSL Receivers
- Battery Powered/Battery Backed Equipment

### DESCRIPTION

The **LT<sup>®</sup>6203X** is a dual low noise, rail-to-rail input and output unity gain stable op amp that features 1.9nV/√Hz noise voltage and draws only 2.5mA of supply current per amplifier. These amplifiers combine very low noise and supply current with a 100MHz gain bandwidth product, a 25V/μs slew rate, and are optimized for low supply signal conditioning systems.

These amplifiers maintain their performance for supplies from 2.5V to 12.6V and are specified at 3V, 5V and ±5V supplies. Harmonic distortion is less than -80dBc at 1MHz making these amplifiers suitable in low power data acquisition systems.

These devices can be used as plug-in replacements for many op amps to improve input/output range and noise performance.

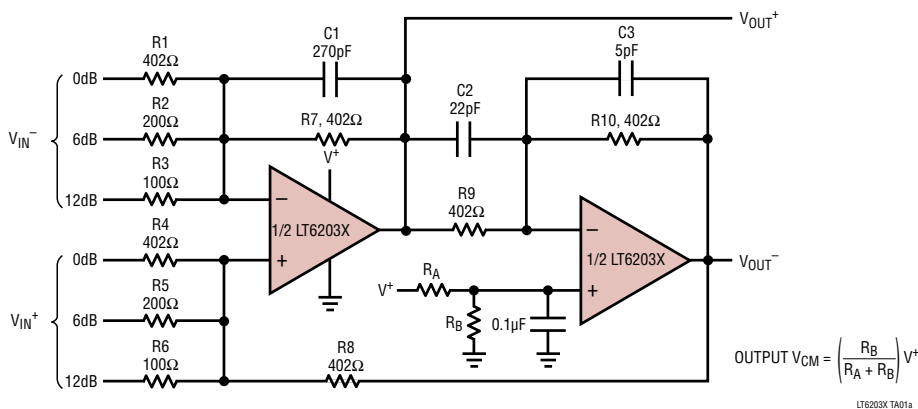
The LT6203X is a member of a growing series of high temperature qualified products offered by Linear Technology<sup>®</sup>. For a complete selection of high temperature products, please consult our website, [www.linear.com](http://www.linear.com).

The LT6203X comes in an 8-pin SO package with standard dual op amp pinout. The LT6203X is also available as dice.

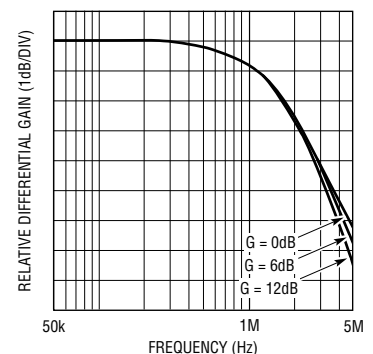
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### TYPICAL APPLICATION

#### Low Noise Differential Amplifier with Gain Adjust and Common Mode Control



#### Low Noise Differential Amplifier Frequency Response



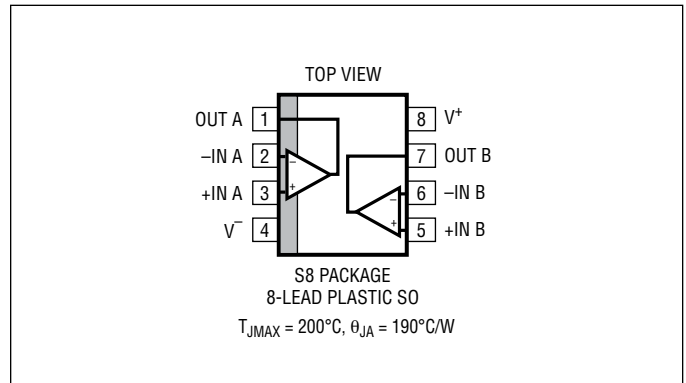
# LT6203X

## ABSOLUTE MAXIMUM RATINGS

(Note 1)

|   |  |
|---|--|
| Total Supply Voltage ( $V^+$ to $V^-$ ) .....         | 12.6V                                      |
| Input Current (Note 2) .....                          | $\pm 40\text{mA}$                          |
| Output Short-Circuit Duration<br>(Note 3) .....       | Thermally Limited                          |
| Operating Temperature Range (Note 4)<br>LT6203X ..... | $-40^\circ\text{C}$ to $175^\circ\text{C}$ |
| Junction Temperature .....                            | $200^\circ\text{C}$                        |
| Storage Temperature Range .....                       | $-65^\circ\text{C}$ to $200^\circ\text{C}$ |
| Lead Temperature (Soldering, 10 sec) .....            | $300^\circ\text{C}$                        |

## PIN CONFIGURATION



## ORDER INFORMATION

(<http://www.linear.com/product/LT6203X#orderinfo>)

| LEAD FREE FINISH | TAPE AND REEL   | PART MARKING | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE                |
|------------------|-----------------|--------------|---------------------|--|
| LT6203XS8#PBF    | LT6203XS8#TRPBF | 6203X        | 8-Lead Plastic SO   | $-40^\circ\text{C}$ to $175^\circ\text{C}$ |

\*The temperature grade is identified by a label on the shipping container

For more information on lead free part marking, go to: <http://www.linear.com/leadfree/>

For more information on tape and reel specifications, go to: <http://www.linear.com/tapeandreel/>. Some packages are available in 500 unit reels through designated sales channels with #TRMPBF suffix.

## ELECTRICAL CHARACTERISTICS

$T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{V}, 0\text{V}$ ;  $V_S = 3\text{V}, 0\text{V}$ ;  $V_{CM} = V_{OUT} = \text{half supply}$ ,

unless otherwise noted.

| SYMBOL       | PARAMETER   | CONDITIONS   | MIN  | TYP  | MAX  | UNITS         |
|--------------|---|--|------|------|------|---------------|
| $V_{OS}$     | Input Offset Voltage  | $V_S = 5\text{V}, 0\text{V}, V_{CM} = \text{Half Supply}$  |      | 0.1  | 0.5  | mV            |
|              |   | $V_S = 3\text{V}, 0\text{V}, V_{CM} = \text{Half Supply}$  |      | 0.6  | 1.5  | mV            |
|              |   | $V_S = 5\text{V}, 0\text{V}, V_{CM} = V^+ \text{ to } V^-$ |      | 0.25 | 2.0  | mV            |
|              |   | $V_S = 3\text{V}, 0\text{V}, V_{CM} = V^+ \text{ to } V^-$ |      | 1.0  | 3.5  | mV            |
|              | Input Offset Voltage Match<br>(Channel-to-Channel) (Note 5) | $V_{CM} = \text{Half Supply}$                              |      | 0.15 | 0.8  | mV            |
|              |   | $V_{CM} = V^- \text{ to } V^+$                             |      | 0.3  | 1.8  | mV            |
| $I_B$        | Input Bias Current  | $V_{CM} = \text{Half Supply}$                              | -7.0 | -1.3 |      | $\mu\text{A}$ |
|              |   | $V_{CM} = V^+$   |      | 1.3  | 2.5  | $\mu\text{A}$ |
|              |   | $V_{CM} = V^-$   | -8.8 | -3.3 |      | $\mu\text{A}$ |
| $\Delta I_B$ | $I_B$ Shift   | $V_{CM} = V^- \text{ to } V^+$                             |      | 4.7  | 11.3 | $\mu\text{A}$ |
|              | $I_B$ Match (Channel-to-Channel) (Note 5)                   |  |      | 0.1  | 0.6  | $\mu\text{A}$ |

**ELECTRICAL CHARACTERISTICS**  $T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $0\text{V}$ ;  $V_S = 3\text{V}$ ,  $0\text{V}$ ;  $V_{\text{CM}} = V_{\text{OUT}} = \text{half supply}$ , unless otherwise noted.

| SYMBOL           | PARAMETER                                     | CONDITIONS   | MIN      | TYP      | MAX  | UNITS                        |
|------------------|---|--|----------|----------|------|------------------------------|
| $I_{\text{OS}}$  | Input Offset Current                          | $V_{\text{CM}} = \text{Half Supply}$   |          | 0.12     | 1    | $\mu\text{A}$                |
|                  |   | $V_{\text{CM}} = V^+$  |          | 0.07     | 1    | $\mu\text{A}$                |
|                  |   | $V_{\text{CM}} = V^-$  |          | 0.12     | 1.1  | $\mu\text{A}$                |
|                  | Input Noise Voltage                           | 0.1Hz to 10Hz  |          | 800      |      | $\text{nV}_{\text{P-P}}$     |
| $e_n$            | Input Noise Voltage Density                   | $f = 100\text{kHz}$ , $V_S = 5\text{V}$  |          | 2        |      | $\text{nV}/\sqrt{\text{Hz}}$ |
|                  |   | $f = 10\text{kHz}$ , $V_S = 5\text{V}$   |          | 2.9      | 4.5  | $\text{nV}/\sqrt{\text{Hz}}$ |
| $i_n$            | Input Noise Current Density, Balanced         | $f = 10\text{kHz}$ , $V_S = 5\text{V}$   |          | 0.75     |      | $\text{pA}/\sqrt{\text{Hz}}$ |
|                  | Input Noise Current Density, Unbalanced       |  |          | 1.1      |      | $\text{pA}/\sqrt{\text{Hz}}$ |
| $C_{\text{IN}}$  | Input Capacitance                             | Common Mode  |          | 4        |      | $\text{M}\Omega$             |
|                  |   | Differential Mode  |          | 12       |      | $\text{k}\Omega$             |
| $A_{\text{VOL}}$ | Large Signal Gain                             | $V_S = 5\text{V}$ , $V_O = 0.5\text{V}$ to $4.5\text{V}$ , $R_L = 1\text{k}$ to $V_S/2$  | 40       | 70       |      | $\text{V}/\text{mV}$         |
|                  |   | $V_S = 5\text{V}$ , $V_O = 1\text{V}$ to $4\text{V}$ , $R_L = 100$ to $V_S/2$            | 8.0      | 14       |      | $\text{V}/\text{mV}$         |
|                  |   | $V_S = 3\text{V}$ , $V_O = 0.5\text{V}$ to $2.5\text{V}$ , $R_L = 1\text{k}$ to $V_S/2$  | 17       | 40       |      | $\text{V}/\text{mV}$         |
| CMRR             | Common Mode Rejection Ratio                   | $V_S = 5\text{V}$ , $V_{\text{CM}} = V^-$ to $V^+$                                       | 60       | 83       |      | $\text{dB}$                  |
|                  |   | $V_S = 5\text{V}$ , $V_{\text{CM}} = 1.5\text{V}$ to $3.5\text{V}$                       | 80       | 100      |      | $\text{dB}$                  |
|                  |   | $V_S = 3\text{V}$ , $V_{\text{CM}} = V^-$ to $V^+$                                       | 56       | 80       |      | $\text{dB}$                  |
|                  | CMRR Match (Channel-to-Channel) (Note 5)      | $V_S = 5\text{V}$ , $V_{\text{CM}} = 1.5\text{V}$ to $3.5\text{V}$                       | 85       | 120      |      | $\text{dB}$                  |
| PSRR             | Power Supply Rejection Ratio                  | $V_S = 2.5\text{V}$ to $10\text{V}$ , $V_{\text{CM}} = 0\text{V}$                        | 60       | 74       |      | $\text{dB}$                  |
|                  | PSRR Match (Channel-to-Channel) (Note 5)      | $V_S = 2.5\text{V}$ to $10\text{V}$ , $V_{\text{CM}} = 0\text{V}$                        | 70       | 100      |      | $\text{dB}$                  |
|                  | Minimum Supply Voltage (Note 6)               |  | 2.5      |          |      | $\text{V}$                   |
| $V_{\text{OL}}$  | Output Voltage Swing LOW Saturation (Note 7)  | No Load  |          | 5        | 50   | $\text{mV}$                  |
|                  |   | $I_{\text{SINK}} = 5\text{mA}$   |          | 85       | 190  | $\text{mV}$                  |
|                  |   | $V_S = 5\text{V}$ , $I_{\text{SINK}} = 20\text{mA}$                                      |          | 240      | 460  | $\text{mV}$                  |
|                  |   | $V_S = 3\text{V}$ , $I_{\text{SINK}} = 15\text{mA}$                                      |          | 185      | 350  | $\text{mV}$                  |
| $V_{\text{OH}}$  | Output Voltage Swing HIGH Saturation (Note 7) | No Load  |          | 25       | 75   | $\text{mV}$                  |
|                  |   | $I_{\text{SOURCE}} = 5\text{mA}$   |          | 90       | 210  | $\text{mV}$                  |
|                  |   | $V_S = 5\text{V}$ , $I_{\text{SOURCE}} = 20\text{mA}$                                    |          | 325      | 600  | $\text{mV}$                  |
|                  |   | $V_S = 3\text{V}$ , $I_{\text{SOURCE}} = 15\text{mA}$                                    |          | 225      | 410  | $\text{mV}$                  |
| $I_{\text{SC}}$  | Short-Circuit Current                         | $V_S = 5\text{V}$  | $\pm 30$ | $\pm 45$ |      | $\text{mA}$                  |
|                  |   | $V_S = 3\text{V}$  | $\pm 25$ | $\pm 40$ |      | $\text{mA}$                  |
| $I_S$            | Supply Current per Amp                        | $V_S = 5\text{V}$  |          | 2.5      | 3.0  | $\text{mA}$                  |
|                  |   | $V_S = 3\text{V}$  |          | 2.3      | 2.85 | $\text{mA}$                  |
| GBW              | Gain Bandwidth Product                        | Frequency = $1\text{MHz}$ , $V_S = 5\text{V}$  |          | 90       |      | $\text{MHz}$                 |
| SR               | Slew Rate                                     | $V_S = 5\text{V}$ , $A_V = -1$ , $R_L = 1\text{k}$ , $V_O = 4\text{V}$                   | 17       | 24       |      | $\text{V}/\mu\text{s}$       |
| FPBW             | Full Power Bandwidth (Note 9)                 | $V_S = 5\text{V}$ , $V_{\text{OUT}} = 3\text{V}_{\text{P-P}}$                            | 1.8      | 2.5      |      | $\text{MHz}$                 |
| $t_S$            | Settling Time                                 | 0.1%, $V_S = 5\text{V}$ , $V_{\text{STEP}} = 2\text{V}$ , $A_V = -1$ , $R_L = 1\text{k}$ |          | 85       |      | $\text{ns}$                  |

## ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over  $-40^{\circ}\text{C} < T_A < 175^{\circ}\text{C}$  temperature range.  $V_S = 5\text{V}, 0\text{V}$ ;  $V_S = 3\text{V}, 0\text{V}$ ;  $V_{\text{CM}} = V_{\text{OUT}} = \text{half supply}$ , unless otherwise noted. (Note 4)

| SYMBOL             | PARAMETER  | CONDITIONS  | MIN   | TYP      | MAX      | UNITS                          |    |
|--------------------|--|---|---|----------|----------|--------------------------------|----|
| $V_{\text{OS}}$    | Input Offset Voltage                                     | $V_S = 5\text{V}, 0\text{V}, V_{\text{CM}} = \text{Half Supply}$                                | ●   | 0.2      | 1.6      | mV                             |    |
|                    |  | $V_S = 3\text{V}, 0\text{V}, V_{\text{CM}} = \text{Half Supply}$                                | ●   | 0.6      | 2.0      | mV                             |    |
|                    |  | $V_S = 5\text{V}, 0\text{V}, V_{\text{CM}} = V^+ \text{ to } V^-$                               | ●   | 1.0      | 5.0      | mV                             |    |
|                    |  | $V_S = 3\text{V}, 0\text{V}, V_{\text{CM}} = V^+ \text{ to } V^-$                               | ●   | 1.4      | 4.5      | mV                             |    |
| $V_{\text{OS TC}}$ | Input Offset Voltage Drift (Note 8)                      | $V_{\text{CM}} = \text{Half Supply}$  | ●   | 3.0      | 9.0      | $\mu\text{V}/^{\circ}\text{C}$ |    |
|                    | Input Offset Voltage Match (Channel-to-Channel) (Note 5) | $V_{\text{CM}} = \text{Half Supply}$  | ●   | 0.3      | 1.5      | mV                             |    |
|                    |  | $V_{\text{CM}} = V^- \text{ to } V^+$   | ●   | 0.7      | 4.0      | mV                             |    |
| $I_B$              | Input Bias Current                                       | $V_{\text{CM}} = \text{Half Supply}$  | ●   | -7.4     | -1.3     | $\mu\text{A}$                  |    |
|                    |  | $V_{\text{CM}} = V^+$   | ●   |          | 1.3      | $\mu\text{A}$                  |    |
|                    |  | $V_{\text{CM}} = V^- + 100\text{mV}$  | ●   | -14.0    | -3.3     | $\mu\text{A}$                  |    |
| $\Delta I_B$       | $I_B$ Shift  | $V_{\text{CM}} = V^- + 100\text{mV} \text{ to } V^+$  | ●   | 4.7      | 16.0     | $\mu\text{A}$                  |    |
|                    | $I_B$ Match (Channel-to-Channel) (Note 5)                |   | ●   | 0.1      | 1.5      | $\mu\text{A}$                  |    |
| $I_{\text{OS}}$    | Input Offset Current                                     | $V_{\text{CM}} = \text{Half Supply}$  | ●   | 0.2      | 1.1      | $\mu\text{A}$                  |    |
|                    |  | $V_{\text{CM}} = V^+$   | ●   | 0.2      | 1.6      | $\mu\text{A}$                  |    |
|                    |  | $V_{\text{CM}} = V^- + 100\text{mV}$  | ●   | 0.2      | 1.7      | $\mu\text{A}$                  |    |
| $A_{\text{VOL}}$   | Large Signal Gain  | $V_S = 5\text{V}, V_O = 0.5\text{V} \text{ to } 4.5\text{V}, R_L = 1\text{k} \text{ to } V_S/2$ | ●   | 29       | 60       | V/mV                           |    |
|                    |  | $V_S = 5\text{V}, V_O = 1.5\text{V} \text{ to } 3.5\text{V}, R_L = 100 \text{ to } V_S/2$       | ●   | 3.7      | 10       | V/mV                           |    |
|                    |  | $V_S = 3\text{V}, V_O = 0.5\text{V} \text{ to } 2.5\text{V}, R_L = 1\text{k} \text{ to } V_S/2$ | ●   | 12       | 32       | V/mV                           |    |
|                    |  |   |   |          |          |                                |    |
| CMRR               | Common Mode Rejection Ratio                              | $V_S = 5\text{V}, V_{\text{CM}} = V^- \text{ to } V^+$  | ●   | 60       | 80       | dB                             |    |
|                    |  | $V_S = 5\text{V}, V_{\text{CM}} = 1.5\text{V} \text{ to } 3.5\text{V}$                          | ●   | 75       | 95       | dB                             |    |
|                    |  | $V_S = 3\text{V}, V_{\text{CM}} = V^- \text{ to } V^+$  | ●   | 50       | 75       | dB                             |    |
|                    | CMRR Match (Channel-to-Channel) (Note 5)                 | $V_S = 5\text{V}, V_{\text{CM}} = 1.5\text{V} \text{ to } 3.5\text{V}$                          | ●   | 80       | 100      | dB                             |    |
| PSRR               | Power Supply Rejection Ratio                             | $V_S = 3\text{V} \text{ to } 10\text{V}, V_{\text{CM}} = 0\text{V}$                             | ●   | 60       | 70       | dB                             |    |
|                    |  | PSRR Match (Channel-to-Channel) (Note 5)  | $V_S = 3\text{V} \text{ to } 10\text{V}, V_{\text{CM}} = 0\text{V}$ | ●        | 70       | 100                            | dB |
|                    |  | Minimum Supply Voltage (Note 6)   | ●   | 3.0      |          | V                              |    |
| $V_{\text{OL}}$    | Output Voltage Swing LOW Saturation (Note 7)             | No Load   | ●   | 6        | 70       | mV                             |    |
|                    |  | $I_{\text{SINK}} = 5\text{mA}$  | ●   | 95       | 220      | mV                             |    |
|                    |  | $I_{\text{SINK}} = 15\text{mA}$   | ●   | 210      | 420      | mV                             |    |
| $V_{\text{OH}}$    | Output Voltage Swing HIGH Saturation (Note 7)            | No Load   | ●   | 55       | 175      | mV                             |    |
|                    |  | $I_{\text{SOURCE}} = 5\text{mA}$  | ●   | 125      | 255      | mV                             |    |
|                    |  | $V_S = 5\text{V}, I_{\text{SOURCE}} = 15\text{mA}$  | ●   | 370      | 650      | mV                             |    |
|                    |  | $V_S = 3\text{V}, I_{\text{SOURCE}} = 15\text{mA}$  | ●   | 270      | 670      | mV                             |    |
| $I_{\text{SC}}$    | Short-Circuit Current                                    | $V_S = 5\text{V}$   | ●   | $\pm 15$ | $\pm 25$ | mA                             |    |
|                    |  | $V_S = 3\text{V}$   | ●   | $\pm 15$ | $\pm 23$ | mA                             |    |
| $I_S$              | Supply Current per Amp                                   | $V_S = 5\text{V}$   | ●   | 3.3      | 6.0      | mA                             |    |
|                    |  | $V_S = 3\text{V}$   | ●   | 3.0      | 5.3      | mA                             |    |
| GBW                | Gain Bandwidth Product                                   | Frequency = 1MHz  | ●   | 83       |          | MHz                            |    |
| SR                 | Slew Rate  | $V_S = 5\text{V}, A_V = -1, R_L = 1\text{k}, V_O = 4\text{V}$                                   | ●   | 12       | 17       | V/ $\mu\text{s}$               |    |
| FPBW               | Full Power Bandwidth (Note 9)                            | $V_S = 5\text{V}, V_{\text{OUT}} = 3\text{V}_{\text{P-P}}$                                      | ●   | 1.3      | 1.8      | MHz                            |    |

**ELECTRICAL CHARACTERISTICS**  $T_A = 25^\circ\text{C}$ ,  $V_S = \pm 5\text{V}$ ;  $V_{CM} = V_{OUT} = 0\text{V}$ , unless otherwise noted.

| SYMBOL       | PARAMETER  | CONDITIONS  | MIN      | TYP        | MAX        | UNITS                  |
|--------------|--|---|----------|------------|------------|------------------------|
| $V_{OS}$     | Input Offset Voltage   | $V_{CM} = 0\text{V}$  |          | 1.0        | 2.5        | mV                     |
|              |  | $V_{CM} = V^+$  |          | 2.6        | 5.5        | mV                     |
|              |  | $V_{CM} = V^-$  |          | 2.3        | 5.0        | mV                     |
|              | Input Offset Voltage Match (Channel-to-Channel) (Note 5)                         | $V_{CM} = 0\text{V}$<br>$V_{CM} = V^- \text{ to } V^+$        |          | 0.2<br>0.4 | 1.0<br>2.0 | mV<br>mV               |
| $I_B$        | Input Bias Current   | $V_{CM} = \text{Half Supply}$                                 | -7.0     | -1.3       |            | $\mu\text{A}$          |
|              |  | $V_{CM} = V^+$  |          | 1.3        | 3.0        | $\mu\text{A}$          |
|              |  | $V_{CM} = V^-$  | -9.5     | -3.8       |            | $\mu\text{A}$          |
| $\Delta I_B$ | $I_B$ Shift  | $V_{CM} = V^- \text{ to } V^+$                                |          | 5.3        | 12.5       | $\mu\text{A}$          |
|              | $I_B$ Match (Channel-to-Channel) (Note 5)  |   |          | 0.1        | 0.6        | $\mu\text{A}$          |
| $I_{OS}$     | Input Offset Current   | $V_{CM} = \text{Half Supply}$                                 |          | 0.15       | 1          | $\mu\text{A}$          |
|              |  | $V_{CM} = V^+$  |          | 0.2        | 1.2        | $\mu\text{A}$          |
|              |  | $V_{CM} = V^-$  |          | 0.35       | 1.3        | $\mu\text{A}$          |
|              | Input Noise Voltage  | 0.1Hz to 10Hz   |          | 800        |            | nV <sub>P-P</sub>      |
| $e_n$        | Input Noise Voltage Density  | $f = 100\text{kHz}$   |          | 1.9        |            | nV/ $\sqrt{\text{Hz}}$ |
|              |  | $f = 10\text{kHz}$  |          | 2.8        | 4.5        | nV/ $\sqrt{\text{Hz}}$ |
| $i_n$        | Input Noise Current Density, Balanced<br>Input Noise Current Density, Unbalanced | $f = 10\text{kHz}$  |          | 0.75       |            | pA/ $\sqrt{\text{Hz}}$ |
|              |  |   |          |            | 1.1        |                        |
| $C_{IN}$     | Input Capacitance  | Common Mode   |          | 4          |            | M $\Omega$             |
|              |  | Differential Mode   |          | 12         |            | k $\Omega$             |
| $C_{IN}$     | Input Capacitance  | Common Mode   |          | 1.8        |            | pF                     |
|              |  | Differential Mode   |          | 1.5        |            | pF                     |
| $A_{VOL}$    | Large Signal Gain  | $V_O = \pm 4.5\text{V}$ , $R_L = 1\text{k}$                   | 75       | 130        |            | V/mV                   |
|              |  | $V_O = \pm 2.5\text{V}$ , $R_L = 100$                         | 11       | 19         |            | V/mV                   |
| CMRR         | Common Mode Rejection Ratio  | $V_{CM} = V^- \text{ to } V^+$                                | 65       | 85         |            | dB                     |
|              |  | $V_{CM} = -2\text{V to } 2\text{V}$                           | 85       | 98         |            | dB                     |
|              | CMRR Match (Channel-to-Channel) (Note 5)   | $V_{CM} = -2\text{V to } 2\text{V}$                           | 85       | 120        |            | dB                     |
| PSRR         | Power Supply Rejection Ratio   | $V_S = \pm 1.25\text{V to } \pm 5\text{V}$                    | 60       | 74         |            | dB                     |
|              |  | $V_S = \pm 1.25\text{V to } \pm 5\text{V}$                    | 70       | 100        |            | dB                     |
| $V_{OL}$     | Output Voltage Swing LOW Saturation (Note 7)                                     | No Load   |          | 5          | 50         | mV                     |
|              |  | $I_{SINK} = 5\text{mA}$                                       |          | 87         | 190        | mV                     |
|              |  | $I_{SINK} = 20\text{mA}$                                      |          | 245        | 460        | mV                     |
| $V_{OH}$     | Output Voltage Swing HIGH Saturation (Note 7)                                    | No Load   |          | 40         | 95         | mV                     |
|              |  | $I_{SOURCE} = 5\text{mA}$                                     |          | 95         | 210        | mV                     |
|              |  | $I_{SOURCE} = 20\text{mA}$                                    |          | 320        | 600        | mV                     |
| $I_{SC}$     | Short-Circuit Current  |   | $\pm 30$ | $\pm 40$   |            | mA                     |
| $I_S$        | Supply Current per Amp   |   |          | 2.8        | 3.5        | mA                     |
| GBW          | Gain Bandwidth Product   | Frequency = 1MHz  | 70       | 100        |            | MHz                    |
| SR           | Slew Rate  | $A_V = -1$ , $R_L = 1\text{k}$ , $V_O = 4\text{V}$            | 18       | 25         |            | V/ $\mu\text{s}$       |
| FPBW         | Full Power Bandwidth (Note 9)  | $V_{OUT} = 3V_{P-P}$  | 1.9      | 2.6        |            | MHz                    |
| $t_S$        | Settling Time  | 0.1%, $V_{STEP} = 2\text{V}$ , $A_V = -1$ , $R_L = 1\text{k}$ |          | 78         |            | ns                     |
| dG           | Differential Gain (Note 10)  | $A_V = 2$ , $R_F = R_G = 499\Omega$ , $R_L = 2\text{k}$       |          | 0.05       |            | %                      |
| dP           | Differential Phase (Note 10)   | $A_V = 2$ , $R_F = R_G = 499\Omega$ , $R_L = 2\text{k}$       |          | 0.03       |            | DEG                    |

## ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over  $-40^{\circ}\text{C} < T_A < 175^{\circ}\text{C}$  temperature range.  $V_S = \pm 5\text{V}$ ;  $V_{\text{CM}} = V_{\text{OUT}} = 0\text{V}$ , unless otherwise noted. (Note 4)

| SYMBOL                | PARAMETER  | CONDITIONS   |   | MIN      | TYP      | MAX  | UNITS                          |
|-----------------------|--|--|---|----------|----------|------|--------------------------------|
| $V_{\text{OS}}$       | Input Offset Voltage                               | $V_{\text{CM}} = 0\text{V}$                              | ● |          | 1.7      | 3.7  | mV                             |
|                       |  | $V_{\text{CM}} = V^+$                                    | ● |          | 3.8      | 9.1  | mV                             |
|                       |  | $V_{\text{CM}} = V^-$                                    | ● |          | 3.5      | 7.6  | mV                             |
| $V_{\text{OS TC}}$    | Input Offset Voltage Drift (Note 8)                | $V_{\text{CM}} = \text{Half Supply}$                     | ● |          | 7.5      | 24   | $\mu\text{V}/^{\circ}\text{C}$ |
|                       |  | Input Offset Voltage Match (Channel-to-Channel) (Note 5) |   |          | 0.3      | 1.2  | mV                             |
| $I_{\text{B}}$        | Input Bias Current                                 | $V_{\text{CM}} = \text{Half Supply}$                     | ● | -7.3     | -1.4     |      | $\mu\text{A}$                  |
|                       |  | $V_{\text{CM}} = V^+$                                    | ● |          | 1.8      | 12.0 | $\mu\text{A}$                  |
|                       |  | $V_{\text{CM}} = V^- + 100\text{mV}$                     | ● | -17.0    | -4.5     |      | $\mu\text{A}$                  |
| $\Delta I_{\text{B}}$ | $I_{\text{B}}$ Shift                               | $V_{\text{CM}} = V^- + 100\text{mV}$ to $V^+$            | ● |          | 5.4      | 25   | $\mu\text{A}$                  |
|                       | $I_{\text{B}}$ Match (Channel-to-Channel) (Note 5) |  | ● |          | 0.15     | 3.0  | $\mu\text{A}$                  |
| $I_{\text{OS}}$       | Input Offset Current                               | $V_{\text{CM}} = \text{Half Supply}$                     | ● |          | 0.15     | 1.1  | $\mu\text{A}$                  |
|                       |  | $V_{\text{CM}} = V^+$                                    | ● |          | 0.3      | 2.8  | $\mu\text{A}$                  |
|                       |  | $V_{\text{CM}} = V^- + 100\text{mV}$                     | ● |          | 0.5      | 2.8  | $\mu\text{A}$                  |
| $A_{\text{VOL}}$      | Large Signal Gain                                  | $V_0 = \pm 4.5\text{V}$ , $R_L = 1\text{k}$              | ● | 54       | 110      |      | V/mV                           |
|                       |  | $V_0 = \pm 1.5\text{V}$ , $R_L = 100$                    | ● | 5.7      | 13       |      | V/mV                           |
| CMRR                  | Common Mode Rejection Ratio                        | $V_{\text{CM}} = V^-$ to $V^+$                           | ● | 65       | 84       |      | dB                             |
|                       |  | $V_{\text{CM}} = -2\text{V}$ to $2\text{V}$              | ● | 79       | 95       |      | dB                             |
| PSRR                  | Power Supply Rejection Ratio                       | $V_S = \pm 1.5\text{V}$ to $\pm 5\text{V}$               | ● | 60       | 70       |      | dB                             |
|                       |  | PSRR Match (Channel-to-Channel) (Note 5)                 | ● | 70       | 100      |      | dB                             |
| $V_{\text{OL}}$       | Output Voltage Swing LOW Saturation (Note 7)       | No Load  | ● |          | 7        | 75   | mV                             |
|                       |  | $I_{\text{SINK}} = 5\text{mA}$                           | ● |          | 98       | 215  | mV                             |
|                       |  | $I_{\text{SINK}} = 15\text{mA}$                          | ● |          | 260      | 500  | mV                             |
| $V_{\text{OH}}$       | Output Voltage Swing HIGH Saturation (Note 7)      | No Load  | ● |          | 70       | 200  | mV                             |
|                       |  | $I_{\text{SOURCE}} = 5\text{mA}$                         | ● |          | 130      | 270  | mV                             |
|                       |  | $I_{\text{SOURCE}} = 15\text{mA}$                        | ● |          | 360      | 640  | mV                             |
| $I_{\text{SC}}$       | Short-Circuit Current                              |  | ● | $\pm 15$ | $\pm 25$ |      | mA                             |
| $I_{\text{S}}$        | Supply Current per Amp                             |  | ● |          | 3.8      | 6.3  | mA                             |
| GBW                   | Gain Bandwidth Product                             | Frequency = 1MHz   | ● |          | 90       |      | MHz                            |
| SR                    | Slew Rate  | $A_V = -1$ , $R_L = 1\text{k}$ , $V_0 = 4\text{V}$       | ● | 13       | 18       |      | V/ $\mu\text{s}$               |
| FPBW                  | Full Power Bandwidth (Note 9)                      | $V_{\text{OUT}} = 3V_{\text{P-P}}$                       | ● | 1.4      | 1.9      |      | MHz                            |

**Note 1:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

**Note 2:** Inputs are protected by back-to-back diodes and diodes to each supply. If the inputs are taken beyond the supplies or the differential input voltage exceeds 0.7V, the input current must be limited to less than 40mA.

**Note 3:** A heat sink may be required to keep the junction temperature below the absolute maximum rating when the output is shorted indefinitely.

**Note 4:** The LT6203X is guaranteed to meet specified performance from  $-40^{\circ}\text{C}$  to  $175^{\circ}\text{C}$ .

**Note 5:** Matching parameters are the difference between the two amplifiers of the LT6203X. CMRR and PSRR match are defined as follows: CMRR and PSRR are measured in  $\mu\text{V}/\text{V}$  on the identical amplifiers. The difference is calculated between the matching sides in  $\mu\text{V}/\text{V}$ . The result is converted to dB.

**Note 6:** Minimum supply voltage is guaranteed by power supply rejection ratio test.

**Note 7:** Output voltage swings are measured between the output and power supply rails.

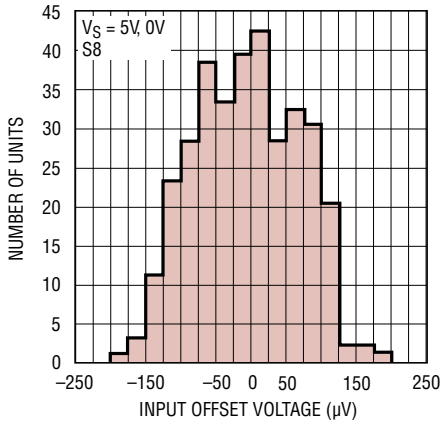
**Note 8:** This parameter is not 100% tested.

**Note 9:** Full-power bandwidth is calculated from the slew rate:  $\text{FPBW} = \text{SR}/2\pi V_{\text{P}}$

**Note 10:** Differential gain and phase are measured using a Tektronix TSG120YC/NTSC signal generator and a Tektronix 1780R Video Measurement Set. The resolution of this equipment is 0.1% and  $0.1^{\circ}$ . Ten identical amplifier stages were cascaded giving an effective resolution of 0.01% and  $0.01^{\circ}$ .

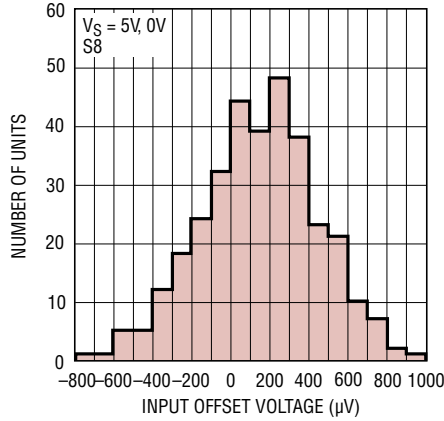
# TYPICAL PERFORMANCE CHARACTERISTICS

**$V_{OS}$  Distribution,  $V_{CM} = V^+/2$**



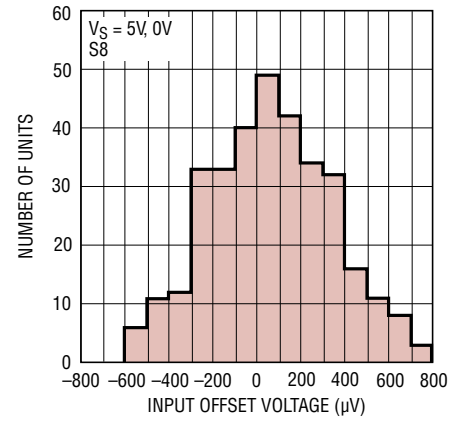
6203X G01

**$V_{OS}$  Distribution,  $V_{CM} = V^+$**



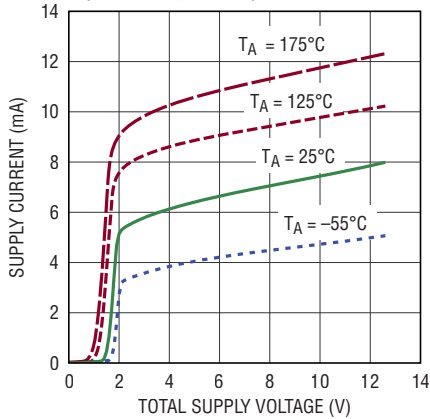
6203X G02

**$V_{OS}$  Distribution,  $V_{CM} = V^-$**



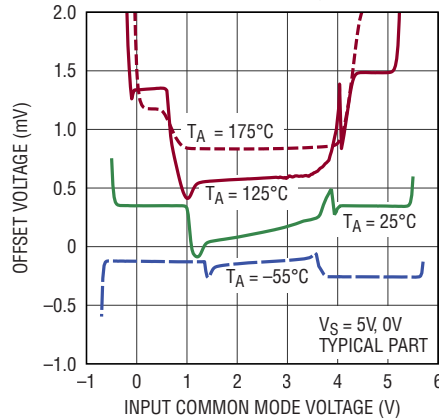
6203X G03

**Supply Current vs Supply Voltage (Both Amplifiers)**



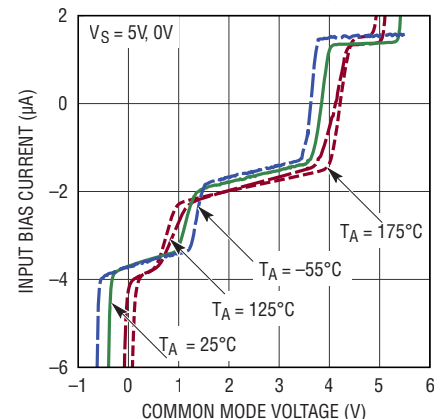
6203X G04

**Offset Voltage vs Input Common Mode Voltage**



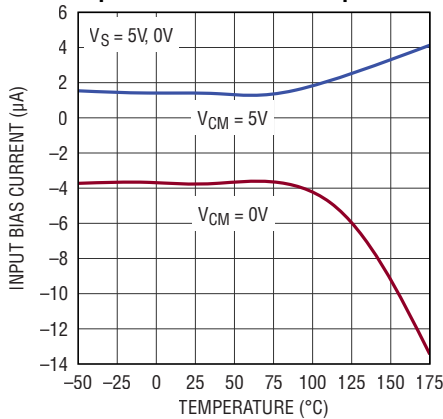
6203X G05

**Input Bias Current vs Common Mode Voltage**



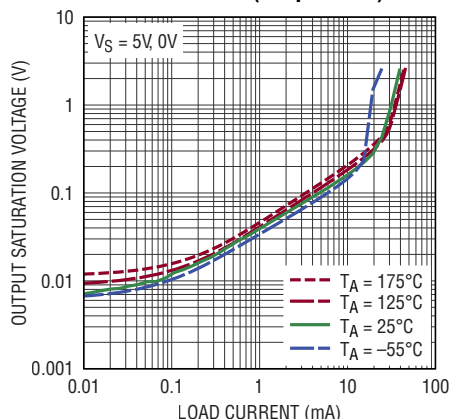
6203X G06

**Input Bias Current vs Temperature**



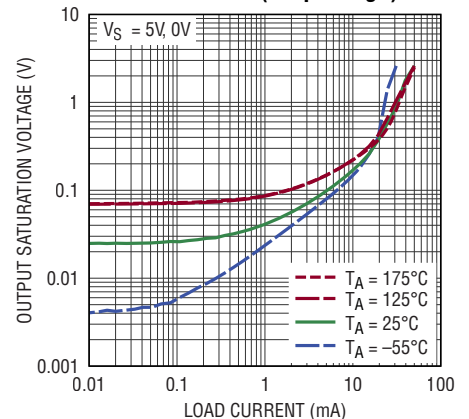
6203X G07

**Output Saturation Voltage vs Load Current (Output Low)**



6203X G08

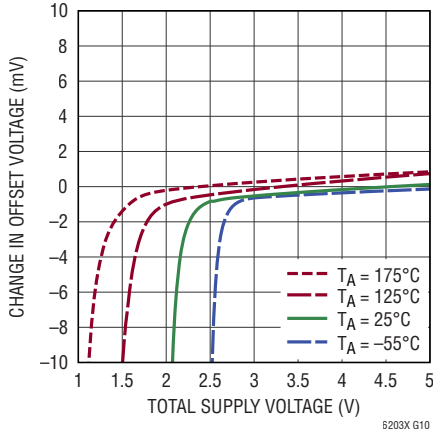
**Output Saturation Voltage vs Load Current (Output High)**



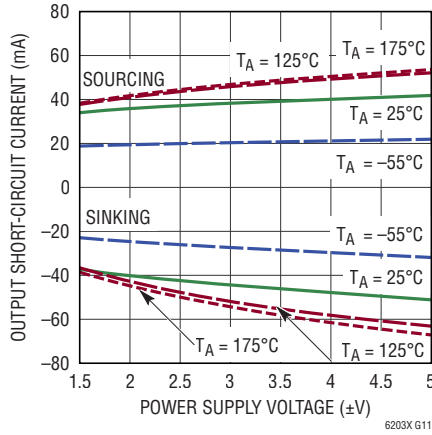
6203X G09

## TYPICAL PERFORMANCE CHARACTERISTICS

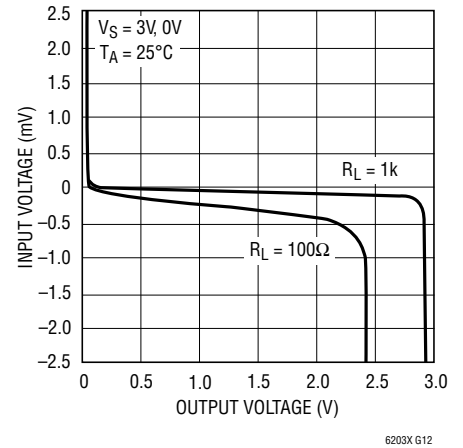
### Minimum Supply Voltage



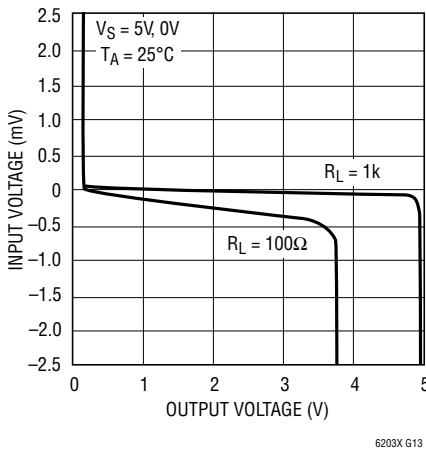
### Output Short-Circuit Current vs Power Supply Voltage



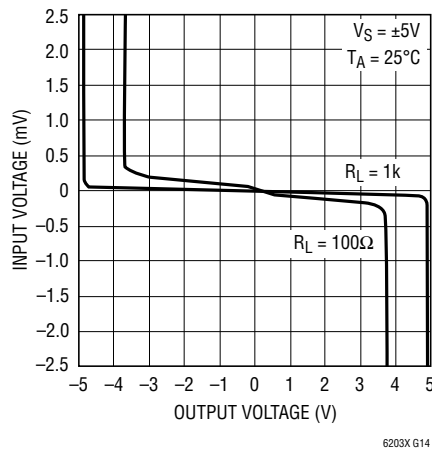
### Open-Loop Gain



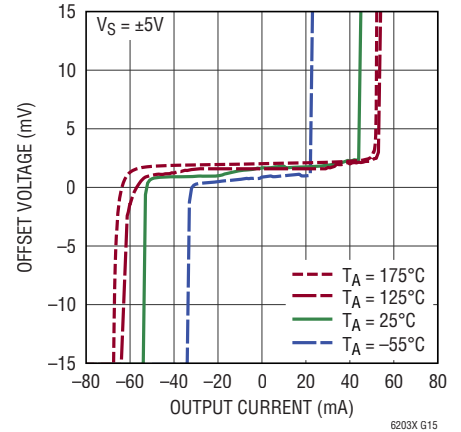
### Open-Loop Gain



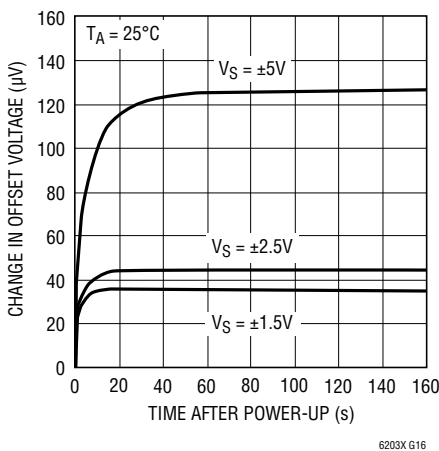
### Open-Loop Gain



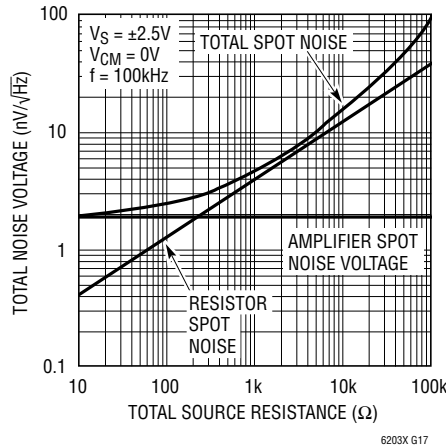
### Offset Voltage vs Output Current



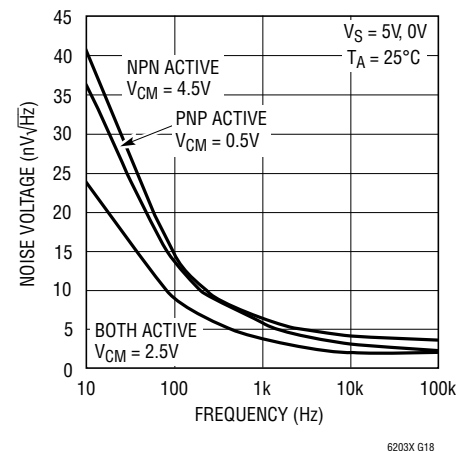
### Warm-Up Drift vs Time (LT6203S8)



### Total Noise vs Total Source Resistance



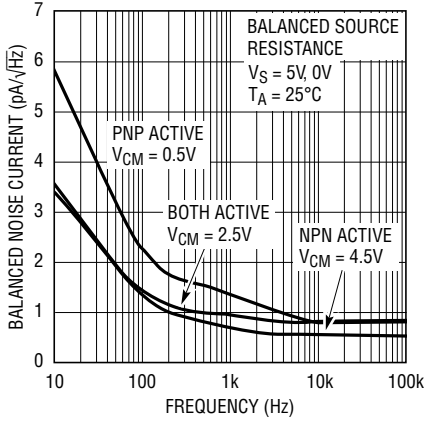
### Input Noise Voltage vs Frequency





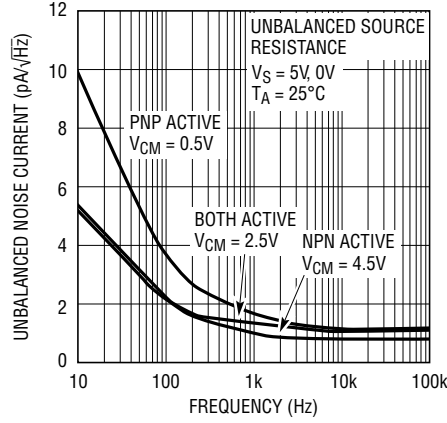
# TYPICAL PERFORMANCE CHARACTERISTICS

**Balanced Noise Current vs Frequency**



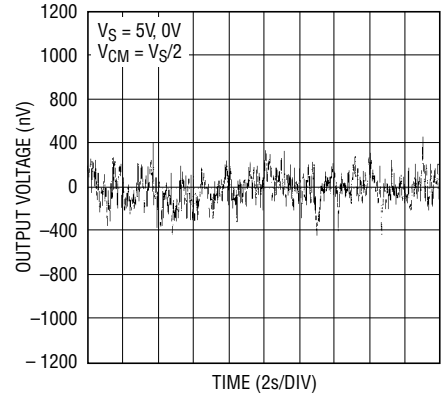
6203X G19

**Unbalanced Noise Current vs Frequency**



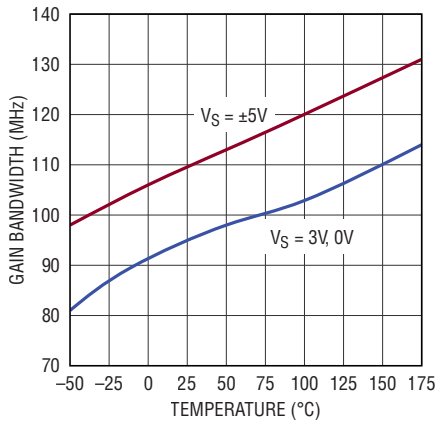
6203X G20

**0.1Hz to 10Hz Output Voltage Noise**



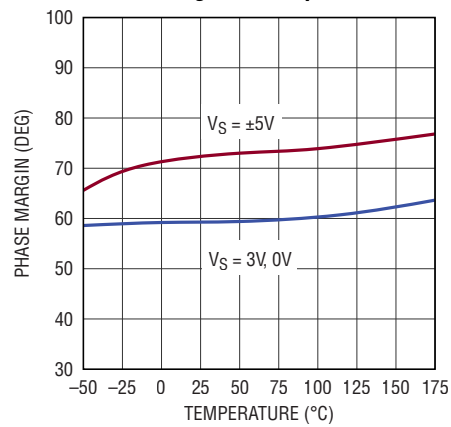
6203X G21

**Gain Bandwidth vs Temperature**



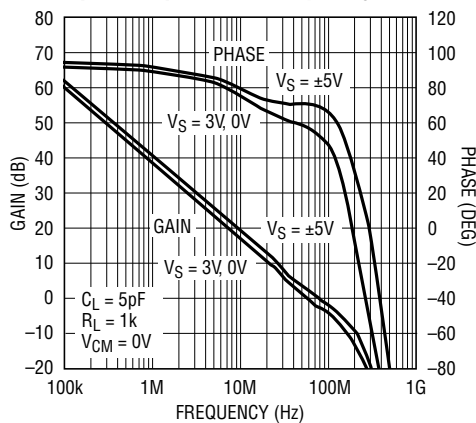
6203X G22

**Phase Margin vs Temperature**



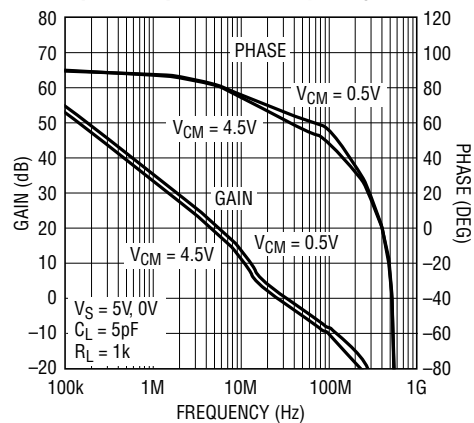
6203X G23

**Open-Loop Gain vs Frequency**



6203X G24

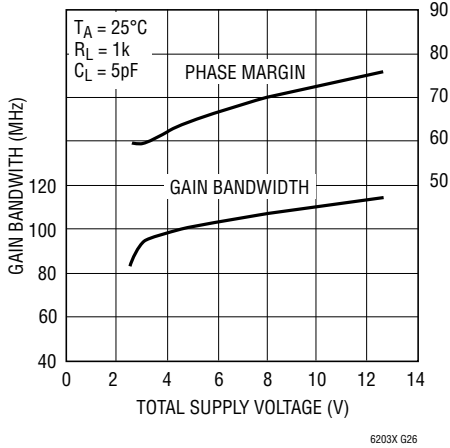
**Open-Loop Gain vs Frequency**



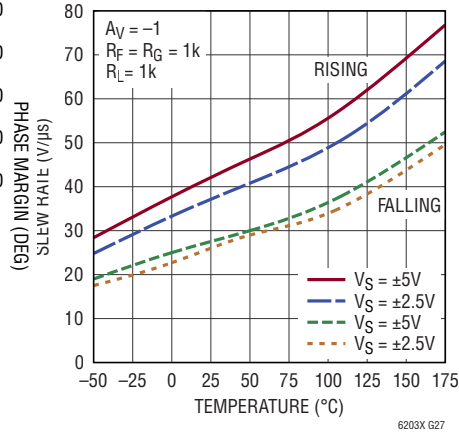
6203X G25

TYPICAL PERFORMANCE CHARACTERISTICS

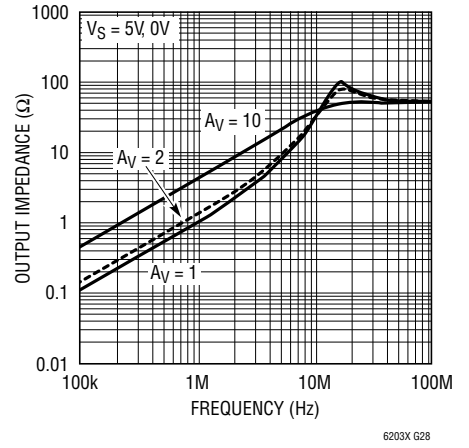
Gain Bandwidth and Phase Margin vs Supply Voltage



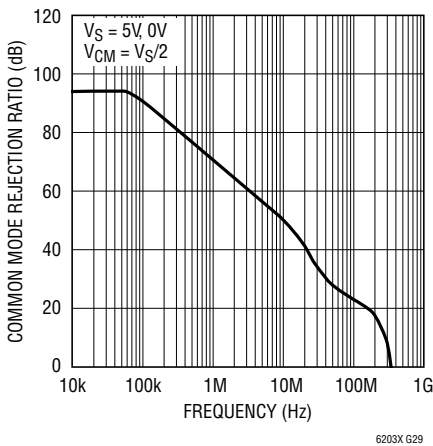
Slew Rate vs Temperature



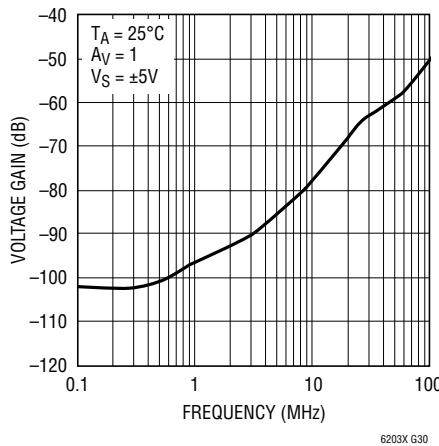
Output Impedance vs Frequency



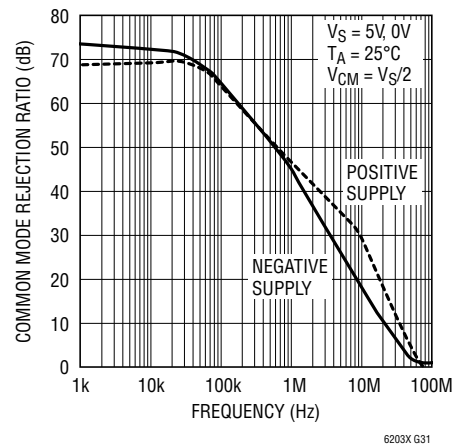
Common Mode Rejection Ratio vs Frequency



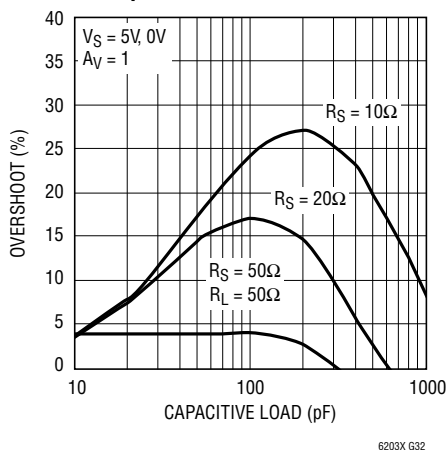
Channel Separation vs Frequency



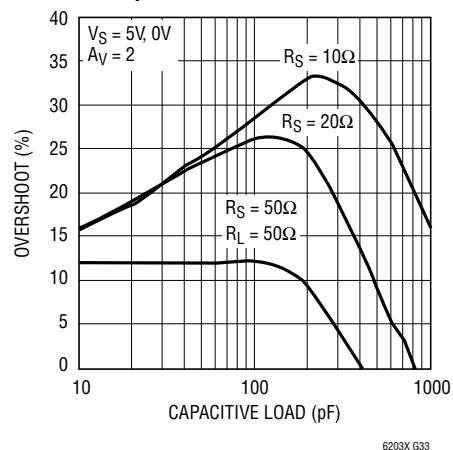
Power Supply Rejection Ratio vs Frequency



Series Output Resistor vs Capacitive Load

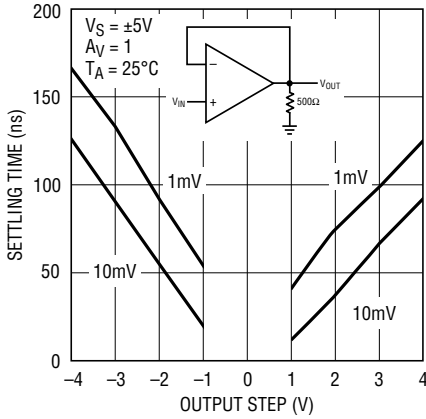


Series Output Resistor vs Capacitive Load



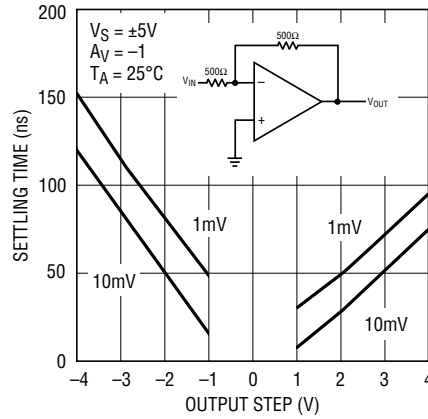
# TYPICAL PERFORMANCE CHARACTERISTICS

**Settling Time vs Output Step (Noninverting)**



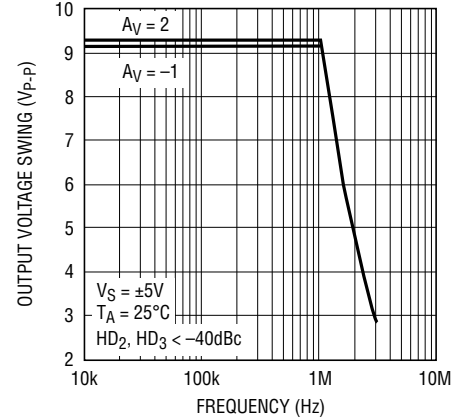
6203X G34

**Settling Time vs Output Step (Inverting)**



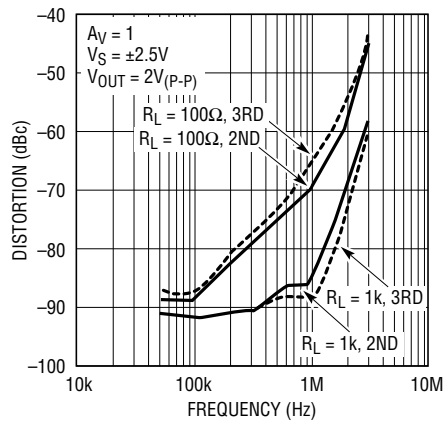
6203X G35

**Maximum Undistorted Output Signal vs Frequency**



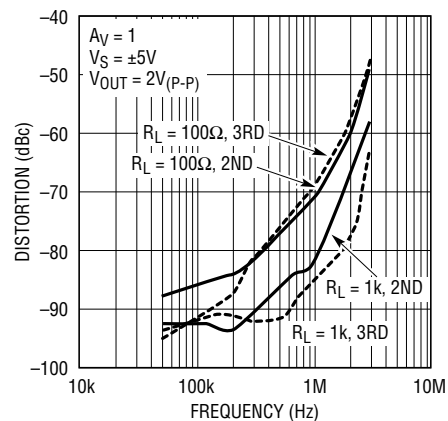
6203X G36

**Distortion vs Frequency**



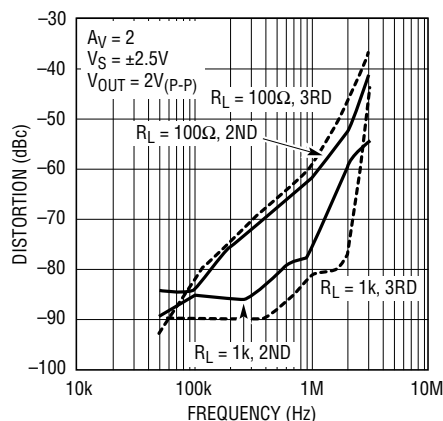
6203X G37

**Distortion vs Frequency**



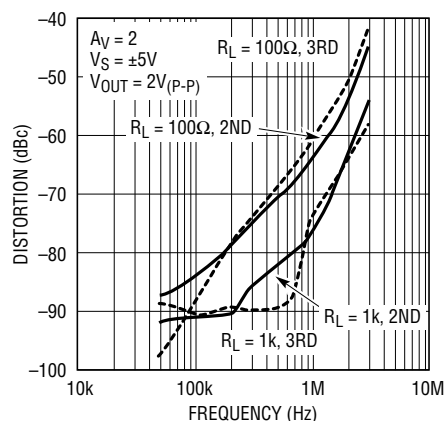
6203X G38

**Distortion vs Frequency**



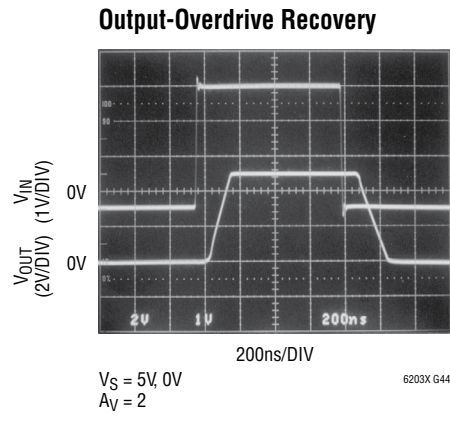
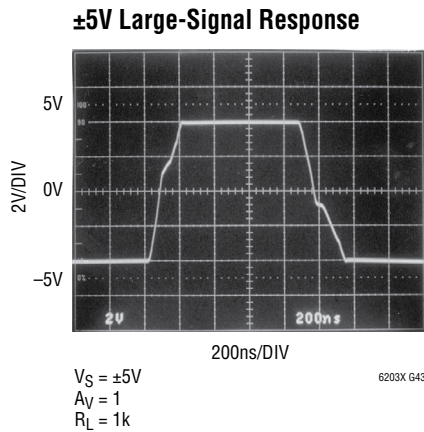
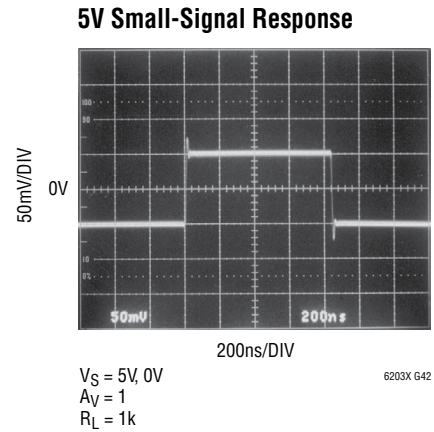
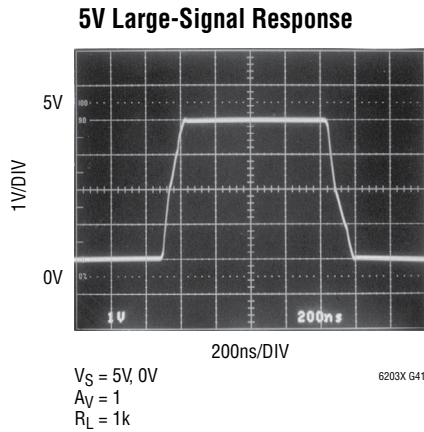
6203X G39

**Distortion vs Frequency**



6203X G40

**TYPICAL PERFORMANCE CHARACTERISTICS**



**PIN FUNCTIONS**

**OUT A (Pin 1):** Amplifier A Output. The output swings rail-to-rail and can source/sink a minimum of 15mA over temperature.

**-IN A (Pin 2):** Inverting Input of Amplifier A. Valid input range is from  $V^-$  to  $V^+$ .

**+IN A (Pin 3):** Non-Inverting Input of Amplifier A. Valid input range is from  $V^-$  to  $V^+$ .

**$V^-$  (Pin 4):** Negative Supply Voltage.  $V^+$  and  $V^-$  must be chosen so that  $3V \leq (V^+ - V^-) < 12.6V$ .

**+IN B (Pin 5):** Non-Inverting Input of Amplifier B. Valid input range from  $V^-$  to  $V^+$ .

**-IN B (Pin 6):** Inverting Input of Amplifier B. Valid input range from  $V^-$  to  $V^+$ .

**OUT B (Pin 7):** Amplifier B Output. The output swings rail-to-rail and can source/sink a minimum of 15mA over temperature.

**$V^+$  (Pin 8):** Positive Supply Voltage.  $V^+$  and  $V^-$  must be chosen so that  $3V \leq (V^+ - V^-) < 12.6V$ .

## APPLICATIONS INFORMATION

### Amplifier Characteristics

Figure 1 shows a simplified schematic of the LT6203X, which has two input differential amplifiers in parallel that are biased on simultaneously when the common mode voltage is at least 1.5V from either rail. This topology allows the input stage to swing from the positive supply voltage to the negative supply voltage. As the common mode voltage swings beyond  $V_{CC} - 1.5V$ , current source  $I_1$  saturates and current in Q1/Q4 is zero. Feedback is maintained through the Q2/Q3 differential amplifier, but with an input  $g_m$  reduction of 1/2. A similar effect occurs with  $I_2$  when the common mode voltage swings within 1.5V of the negative rail. The effect of the  $g_m$  reduction is a shift in the  $V_{OS}$  as  $I_1$  or  $I_2$  saturate.

Input bias current normally flows out of the + and – inputs. The magnitude of this current increases when the input common mode voltage is within 1.5V of the negative rail, and only Q1/Q4 are active. The polarity of this current reverses when the input common mode voltage is within 1.5V of the positive rail and only Q2/Q3 are active.

The second stage is a folded cascode and current mirror that converts the input stage differential signals to a single ended output. Capacitor C1 reduces the unity cross frequency and improves the frequency stability without degrading the gain bandwidth of the amplifier. The differential drive generator supplies current to the output transistors that swing from rail-to-rail.

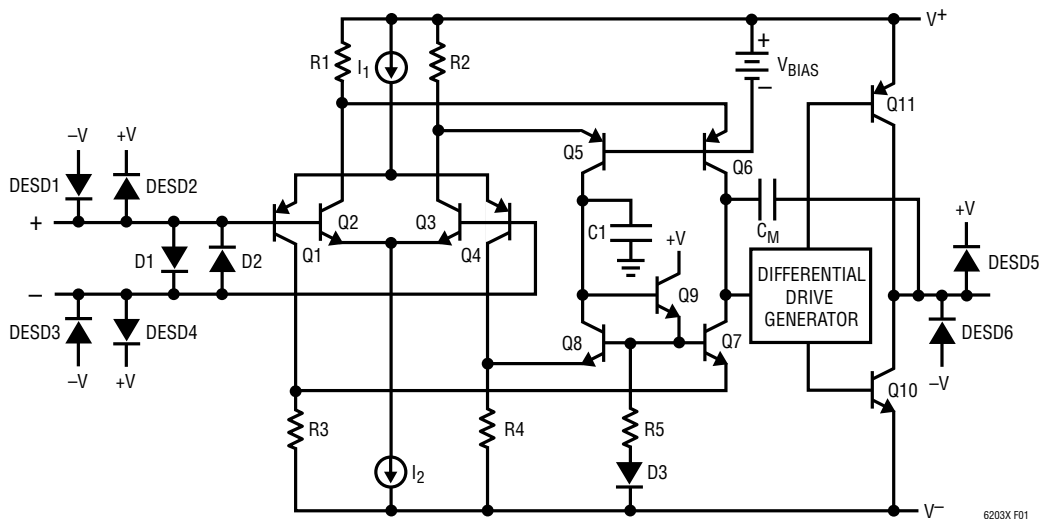


Figure 1. Simplified Schematic

## APPLICATIONS INFORMATION

### Input Protection

There are back-to-back diodes, D1 and D2, across the + and – inputs of these amplifiers to limit the differential input voltage to  $\pm 0.7V$ . The inputs of the LT6203X do not have internal resistors in series with the input transistors. This technique is often used to protect the input devices from over voltage that causes excessive currents to flow. The addition of these resistors would significantly degrade the low noise voltage of these amplifiers. For instance, a  $100\Omega$  resistor in series with each input would generate  $1.8nV/\sqrt{Hz}$  of noise, and the total amplifier noise voltage would rise from  $1.9nV/\sqrt{Hz}$  to  $2.6nV/\sqrt{Hz}$ . Once the input differential voltage exceeds  $\pm 0.7V$ , steady state current conducted through the protection diodes should be limited to  $\pm 40mA$ . This implies  $25\Omega$  of protection resistance per volt of continuous overdrive beyond  $\pm 0.7V$ . The input diodes are rugged enough to handle transient currents due to amplifier slew rate overdrive or momentary clipping without these resistors.

Figure 2 shows the input and output waveforms of the amplifier driven into clipping while connected in a gain of  $A_V = 1$ . When the input signal goes sufficiently beyond the power supply rails, the input transistors will saturate. When saturation occurs, the amplifier loses a stage of phase inversion and the output tries to change states. Diodes D1 and D2 forward bias and hold the output within

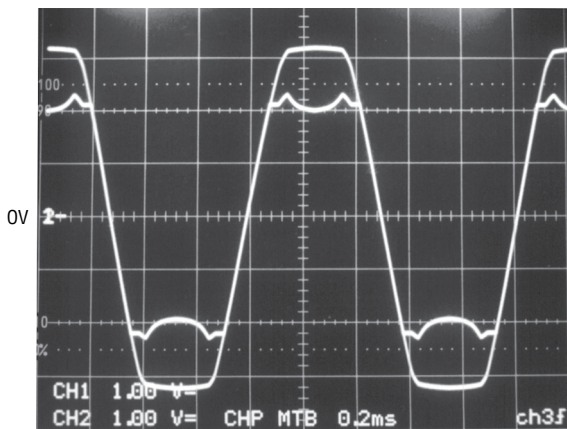


Figure 2.  $V_S = \pm 2.5V$ ,  $A_V = 1$  with Large Overdrive

a diode drop of the input signal. In this photo, the input signal generator is clipping at  $\pm 35mA$ , and the output transistors supply this generator current through the protection diodes.

With the amplifier connected in a gain of  $A_V \geq 2$ , the output can invert with very heavy input overdrive. To avoid this inversion, limit the input overdrive to  $0.5V$  beyond the power supply rails.

### ESD

The LT6203X has reverse-biased ESD protection diodes on all inputs and outputs as shown in Figure 1. If these pins are forced beyond either supply, unlimited current will flow through these diodes. If the current is transient and limited to one hundred milliamps or less, no damage to the device will occur.

### Noise

The noise voltage of the LT6203X is equivalent to that of a  $225\Omega$  resistor, and for the lowest possible noise it is desirable to keep the source and feedback resistance at or below this value, i.e.  $R_S + R_G \parallel R_{FB} \leq 225\Omega$ . With  $R_S + R_G \parallel R_{FB} = 225\Omega$  the total noise of the amplifier is:  $e_n = \sqrt{(1.9nV)^2 + (1.9nV)^2} = 2.7nV$ . Below this resistance value, the amplifier dominates the noise, but in the resistance region between  $225\Omega$  and approximately  $10k\Omega$ , the noise is dominated by the resistor thermal noise. As the total resistance is further increased, beyond  $10k$ , the noise current multiplied by the total resistance eventually dominates the noise.

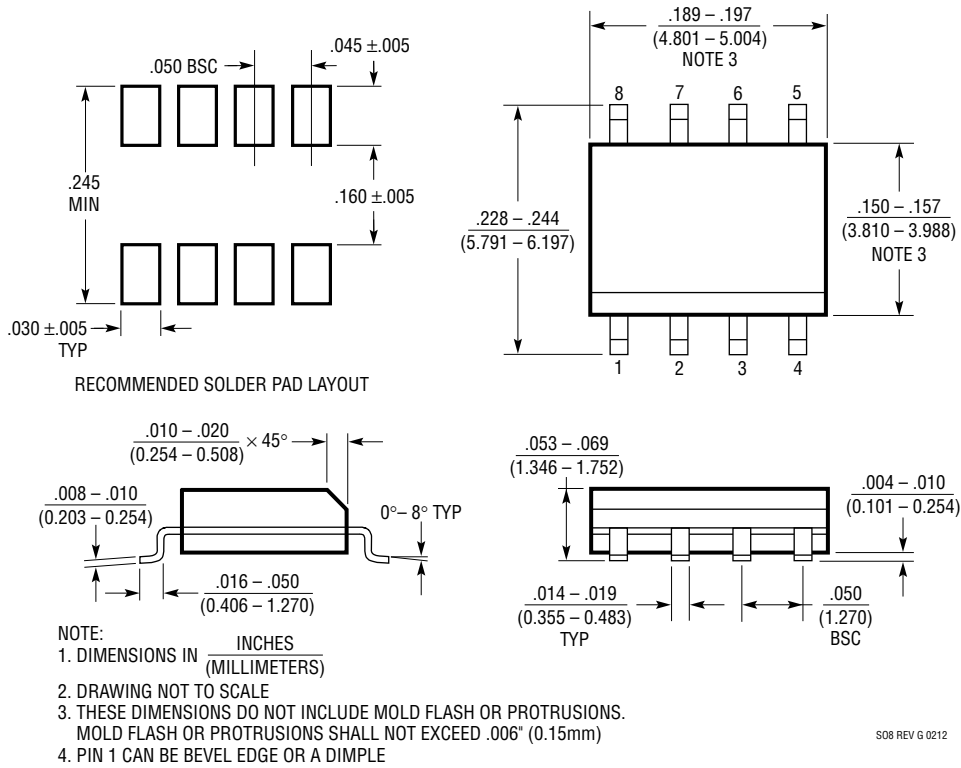
The product of  $e_n \cdot \sqrt{I_{SUPPLY}}$  is an interesting way to gauge low noise amplifiers. Many low noise amplifiers with low  $e_n$  have high  $I_{SUPPLY}$  current. In applications that require low noise with the lowest possible supply current, this product can prove to be enlightening. The LT6203X has an  $e_n \cdot \sqrt{I_{SUPPLY}}$  product of 3.2 per amplifier, yet it is common to see amplifiers with similar noise specifications have an  $e_n \cdot \sqrt{I_{SUPPLY}}$  product of 4.7 to 13.5.

For a complete discussion of amplifier noise, see the LT1028 data sheet.

# PACKAGE DESCRIPTION

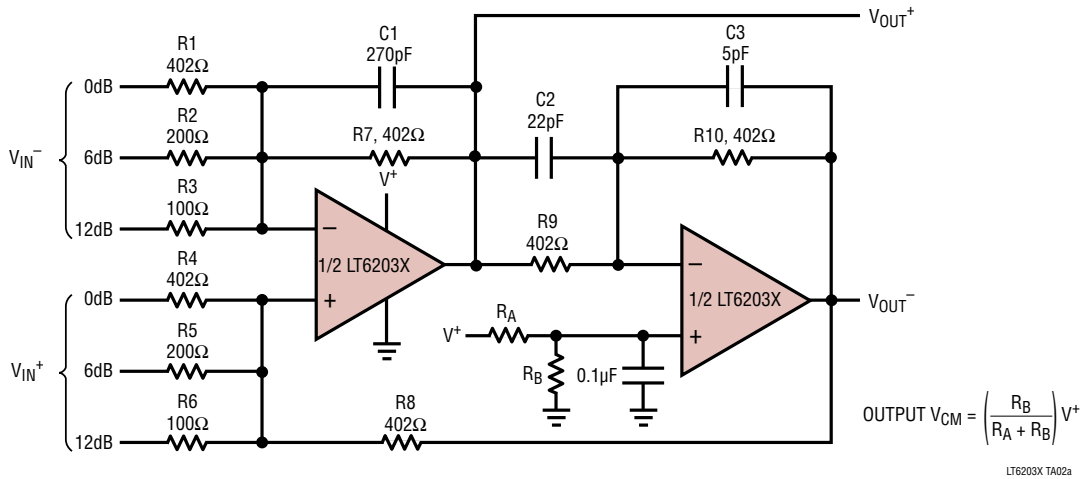
Please refer to <http://www.linear.com/product/LT6203X#packaging> for the most recent package drawings.

## S8 Package 8-Lead Plastic Small Outline (Narrow .150 Inch) (Reference LTC DWG # 05-08-1610 Rev G)

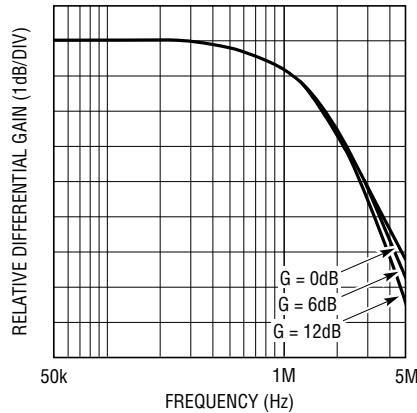


## TYPICAL APPLICATION

### Low Noise Differential Amplifier with Gain Adjust and Common Mode Control



### Low Noise Differential Amplifier Frequency Response



## RELATED PARTS

| PART NUMBER                          | DESCRIPTION   | COMMENTS   |
|--------------------------------------|---|--|
| <a href="#">LT1028</a>               | Single, Ultralow Noise 50MHz Op Amp                   | 0.85nV/ $\sqrt{\text{Hz}}$   |
| <a href="#">LT1677</a>               | Single, Low Noise Rail-to-Rail Amplifier              | 3V Operation, 2.5mA, 4.5nV/ $\sqrt{\text{Hz}}$ , 60 $\mu\text{V}$ Max $V_{OS}$                   |
| <a href="#">LT1722/LT1723/LT1724</a> | Single/Dual/Quad Low Noise Precision Op Amps          | 70V/ $\mu\text{s}$ Slew Rate, 400 $\mu\text{V}$ Max $V_{OS}$ , 3.8nV/ $\sqrt{\text{Hz}}$ , 3.7mA |
| <a href="#">LT1800/LT1801/LT1802</a> | Single/Dual/Quad Low Power 80MHz Rail-to-Rail Op Amps | 8.5nV/ $\sqrt{\text{Hz}}$ , 2mA Max Supply   |
| <a href="#">LT1806/LT1807</a>        | Single/Dual, Low Noise 325MHz Rail-to-Rail Amplifiers | 2.5V Operation, 550 $\mu\text{V}$ Max $V_{OS}$ , 3.5nV/ $\sqrt{\text{Hz}}$                       |
| <a href="#">LT6200</a>               | Single Ultralow Noise Rail-to-Rail Amplifier          | 0.95nV/ $\sqrt{\text{Hz}}$ , 165MHz Gain Bandwidth   |



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- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
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«FORSTAR» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели, кабельные сборки и микроволновые компоненты:

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