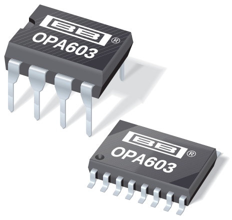
BURR - BROWN®



# OPA603

# High Speed, Current-Feedback, High Voltage OPERATIONAL AMPLIFIER

## FEATURES

- WIDE SUPPLY RANGE: ±4.5 to ±18V
- BANDWIDTH: 100MHz, G = 1 to 10
- SLEW RATE: 1000V/µs
- FAST SETTLING TIME: 50ns to 0.1%
- HIGH OUTPUT CURRENT: ±150mA peak
- HIGH OUTPUT VOLTAGE: ±12V

## APPLICATIONS

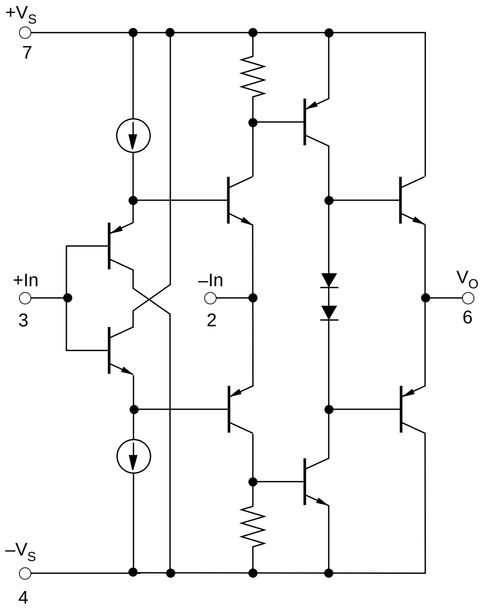
- VIDEO AMPLIFIER
- PULSE AMPLIFIER
- SONAR, ULTRASOUND BUFFERS
- ATE PIN DRIVERS
- xDSL LINE DRIVER
- FAST DATA ACQUISTION
- WAVEFORM GENERATORS

## DESCRIPTION

The OPA603 is a high-speed current-feedback op amp with guaranteed specifications at both ±5V and ±15V power supplies. It can deliver full ±10V signals into 150Ω loads with up to 1000V/µs slew rate. This allows it to drive terminated 75Ω cables. With 150mA peak output current capability it is suitable for driving load capacitance or long lines at high speed.

In contrast with conventional op amps, the current-feedback approach provides nearly constant bandwidth and settling time over a wide range of closed-loop voltage gains.

The OPA603 is available in a plastic 8-pin DIP and SO-16 surface-mount packages, specified over the industrial temperature range.



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Internet: http://www.burr-brown.com/ • FAXLine: (800) 548-6133 (US/Canada Only) • Cable: BBRCORP • Telex: 066-6491 • FAX: (520) 889-1510 • Immediate Product Info: (800) 548-6132

PDS-1026E

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# SPECIFICATIONS: $V_S$ = ±15V

## ELECTRICAL

At $T_A$ = +25°C, and $R_L$ = 150Ω, unless otherwise noted.

| | | OPA603AP, AU | | | |
|---|---|---|---|---|---|
| **PARAMETER** | **CONDITIONS** | **MIN** | **TYP** | **MAX** | **UNITS** |
| **INPUT OFFSET VOLTAGE** | | | | | |
| Initial | | | | 5 | mV |
| vs Temperature | | | 8 | | μV/°C |
| vs Common-Mode Voltage | $V_{CM}$ = ±10V | 50 | 60 | | dB |
| vs Supply (tracking) Voltage | $V_S$ = ±12V to ±18V | 80 | 85 | | dB |
| vs Supply (non-tracking)(1) | $\lvert V_S \rvert$ = 12V to 18V | 55 | 60 | | dB |
| **+INPUT BIAS CURRENT** | | | | | |
| Initial | | | | 5 | μA |
| vs Temperature | | | 30 | | nA/°C |
| vs Common-Mode | $V_{CM}$ = ±10V | | 200 | 500 | nA/V |
| vs Supply (tracking) | $V_S$ = ±12V to ±18V | | 50 | 100 | nA/V |
| vs Supply (non-tracking)(1) | $\lvert V_S \rvert$ = 12V to 18V | | 150 | 300 | nA/V |
| **–INPUT BIAS CURRENT** | | | | | |
| Initial | | | | 25 | μA |
| vs Temperature | | | 300 | | nA/°C |
| vs Common-Mode | $V_{CM}$ = ±10V | | 200 | 600 | nA/V |
| vs Supply (tracking) | $V_S$ = ±12V to ±18V | | 300 | 500 | nA/V |
| vs Supply (non-tracking)(1) | $\lvert V_S \rvert$ = 12V to 18V | | 1500 | 2000 | nA/V |
| **INPUT IMPEDANCE** | | | | | |
| +Input | | | 5 \|\| 2 | | MΩ \|\| pF |
| –Input | | | 30 \|\| 2 | | Ω \|\| pF |
| **OPEN LOOP CHARACTERISTICS** | | | | | |
| Transresistance | $V_O$ = ±10V | 300 | 440 | | kΩ |
| Transcapacitance | | | 1.8 | | pF |
| **OUTPUT CHARACTERISTICS** | | | | | |
| Voltage | $R_L$ = 150Ω | ±10 | ±12 | | V |
| Peak Current | | | 150 | | mA |
| Short-Circuit Current(2) | $V_O$ = 0V | | 250 | | mA |
| Output Resistance, Open-Loop | | | 70 | | Ω |
| **FREQUENCY RESPONSE** | G = +2 | | | | |
| Small-Signal Bandwidth(3) | | 70 | 160 | | MHz |
| Gain Flatness, ±0.5dB | | 35 | 75 | | MHz |
| Full-Power Bandwidth | $V_O$ = 20Vp-p | | 10 | | MHz |
| Differential Gain | f = 4.43MHz, $V_O$ = 1V | | 0.03 | | % |
| Differential Phase | f = 4.43MHz, $V_O$ = 1V | | 0.025 | | Degrees |
| **TIME DOMAIN RESPONSE** | G = +2 | | | | |
| Propagation Delay | | | 10 | | ns |
| Rise and Fall Time | | | 10 | | ns |
| Settling Time to 0.10% | 10V Step | | 50 | | ns |
| Slew Rate | | | 1000 | | V/μs |
| **DISTORTION** | G = +2, $R_L$ = 100Ω, f = 10MHz | | | | |
| 2nd Harmonic Distortion | $V_O$ = 0.2Vp-p | –60 | –65 | | dBc |
| 3rd Harmonic Distortion | $V_O$ = 0.2Vp-p | –70 | –90 | | dBc |
| **POWER SUPPLY** | | | | | |
| Specified Operating Voltage | | | ±15 | | V |
| Operating Voltage Range | | ±4.5 | | ±18 | V |
| Current | | | ±21 | ±25 | mA |
| **TEMPERATURE RANGE** | | | | | |
| Specification | | –25 | | +85 | °C |
| Storage | | –40 | | +150 | °C |
| **THERMAL RESISTANCE, $\theta_{JA}$** | Soldered to Printed Circuit | | 90 | | °C/W |

NOTES: (1) One power supply fixed at 15V; the other supply varied from 12V to 18V. (2) Observe power derating curve. (3) See bandwidth versus gain curve, Figure 5.

# SPECIFICATIONS: $V_S$ = ±5V

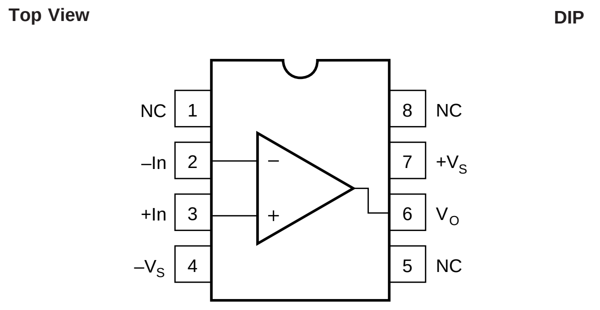
## ELECTRICAL

At $T_A$ = +25°C, and $R_L$= 75Ω, unless otherwise noted.

| | | OPA603AP, AU | | | |
|---|---|---|---|---|---|
| **PARAMETER** | **CONDITIONS** | **MIN** | **TYP** | **MAX** | **UNITS** |
| **INPUT OFFSET VOLTAGE** | | | | | |
| Initial | | | | 6 | mV |
| vs Temperature | | | 8 | | µV/°C |
| vs Common-Mode | $V_{CM}$ = ±3V | 50 | 55 | | dB |
| vs Supply (tracking) | $V_S$ = ±4V to ±6V | 75 | 80 | | dB |
| vs Supply (non-tracking)(1) | $\lvert V_S \rvert$ = 4V to 6V | 55 | 60 | | dB |
| **+INPUT BIAS CURRENT** | | | | | |
| Initial | | | | 5 | µA |
| vs Temperature | | | 30 | | nA/°C |
| vs Common-Mode | $V_{CM}$ = ±3V | | 350 | 600 | nA/V |
| vs Supply (tracking) | $V_S$ = ±4V to ±6V | | 100 | 200 | nA/V |
| vs Supply (non-tracking)(1) | $\lvert V_S \rvert$ = 4V to 6V | | 200 | 300 | nA/V |
| **–INPUT BIAS CURRENT** | | | | | |
| Initial | | | | 25 | µA |
| vs Temperature | | | 300 | | nA/°C |
| vs Common-Mode | $V_{CM}$ = ±3V | | 300 | 600 | nA/V |
| vs Supply (tracking) | $V_S$ = ±4V to ±6V | | 500 | 700 | nA/V |
| vs Supply (non-tracking)(1) | $\lvert V_S \rvert$ = 4V to 6V | | 2500 | 3000 | nA/V |
| **INPUT IMPEDANCE** | | | | | |
| +Input | | | 3.3 \|\| 2 | | MΩ \|\| pF |
| –Input | | | 30 \|\| 2 | | Ω \|\| pF |
| **OPEN LOOP CHARACTERISTICS** | | | | | |
| Transresistance | $V_O$ = ±2V | 225 | 330 | | kΩ |
| Transcapacitance | | | 2.4 | | pF |
| **OUTPUT CHARACTERISTICS** | | | | | |
| Voltage | $R_L$ = 75Ω | ±2 | ±2.75 | | V |
| Peak Current | | | 150 | | mA |
| Short-Circuit Current(2) | $V_O$ = 0V | | 250 | | mA |
| Output Resistance, Open-Loop | | | 80 | | Ω |
| **FREQUENCY RESPONSE** | G = +2 | | | | |
| Small-Signal Bandwidth(3) | | | 140 | | MHz |
| Gain Flatness, ±0.5dB | | | 65 | | MHz |
| Full-Power Bandwidth | | | 20 | | MHz |
| Differential Gain | f = 4.43MHz, $V_O$ = 1V, $R_L$ = 150Ω | | 0.03 | | % |
| Differential Phase | f = 4.43MHz, $V_O$ = 1V, $R_L$ = 150Ω | | 0.025 | | Degrees |
| **TIME DOMAIN RESPONSE** | G = +2, $R_L$ = 100Ω | | | | |
| Propagation Delay | | | 15 | | ns |
| Rise and Fall Time | | | 20 | | ns |
| Settling Time to 0.10% | | | 60 | | ns |
| Slew Rate | | | 750 | | V/µs |
| **DISTORTION** | G = +2, $R_L$ = 100Ω, f = 10MHz | | | | |
| 2nd Harmonic Distortion | $V_O$ = 0.2Vp-p | | –67 | | dBc |
| 3rd Harmonic Distortion | $V_O$ = 0.2Vp-p | | –78 | | dBc |
| **POWER SUPPLY** | | | | | |
| Specified Operating Voltage | | | ±5 | | V |
| Operating Voltage Range | | ±4.5 | | ±18 | V |
| Current | | | ±21 | ±25 | mA |
| **TEMPERATURE RANGE** | | | | | |
| Specification | | –25 | | +85 | °C |
| Storage | | –40 | | +150 | °C |
| **THERMAL RESISTANCE, $\theta_{JUNCTION\text{-}AMBIENT}$** | Soldered to Printed Circuit | | 90 | | °C/W |

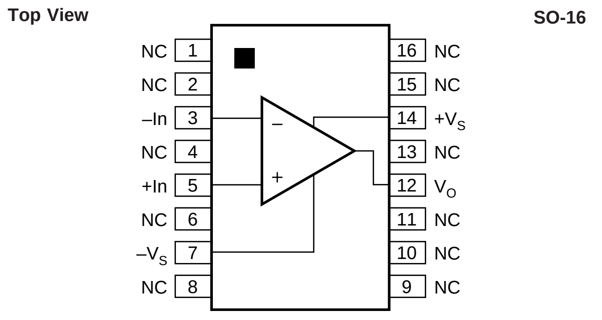
NOTES: (1) One power supply fixed at 5V; the other supply varied from 4V to 6V. (2) Observe power derating curve. (3) See bandwidth versus gain curves, Figure 5.

## PIN CONFIGURATION



NC: No Internal Connection.
Solder to ground plane for
improved heat dissipation.

## PIN CONFIGURATION



NC: No Internal Connection.
Solder to ground plane for
improved heat dissipation.

## ABSOLUTE MAXIMUM RATINGS

| | |
|---|---|
| Supply Voltage | ±18V |
| Input Voltage Range | $\pm V_S$ |
| Differential Input Voltage | ±6V |
| Power Dissipation | See derating curve |
| Operating Temperature | +100°C |
| Storage Temperature | +150°C |
| Junction Temperature | +150°C |
| Lead Temperature (soldering, 10s) | +300°C |
| (soldering SO-16 package, 3s) | +260°C |

## PACKAGE/ORDERING INFORMATION

| PRODUCT | PACKAGE | PACKAGE DRAWING NUMBER[1] | SPECIFIED TEMPERATURE RANGE |
|---|---|---|---|
| OPA603AP | Plastic DIP | 006 | –25°C to +85°C |
| OPA603AU | SO-16 | 211 | –25°C to +85°C |

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

## ELECTROSTATIC DISCHARGE SENSITIVITY

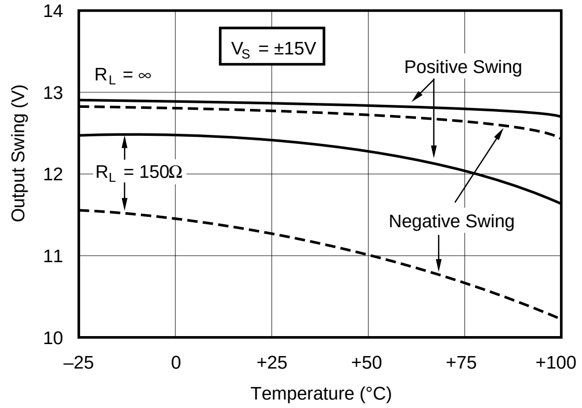
This integrated circuit can be damaged by ESD. Burr-Brown recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

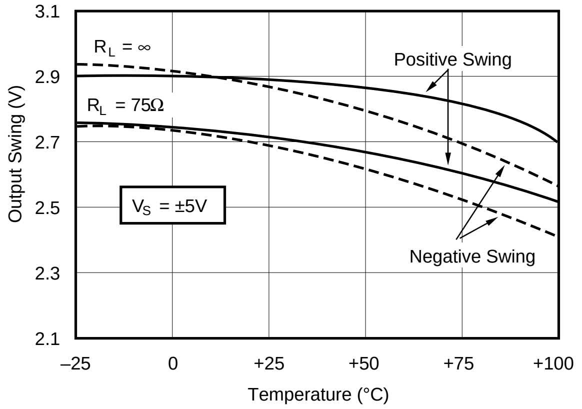
# TYPICAL PERFORMANCE CURVES

At $T_A$ = +25°C, unless otherwise noted.

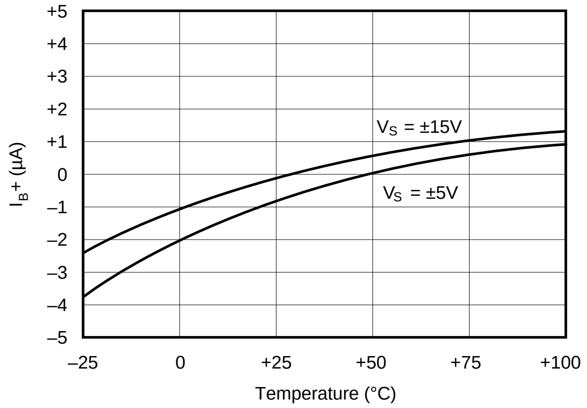
OUTPUT SWING vs TEMPERATURE



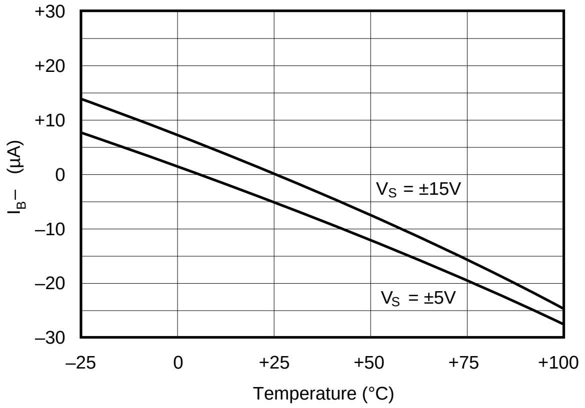
OUTPUT SWING vs TEMPERATURE



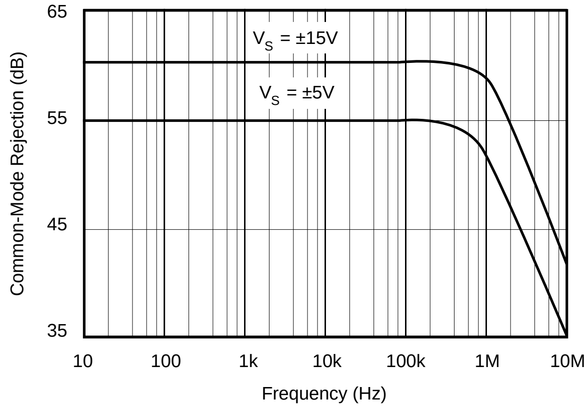
NONINVERTING INPUT BIAS CURRENT vs TEMPERATURE



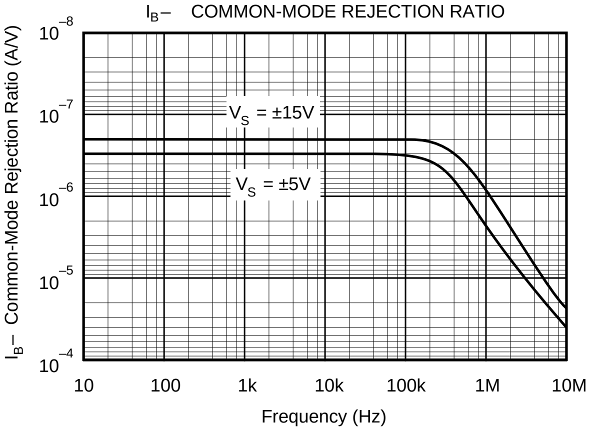
INVERTING INPUT BIAS CURRENT vs TEMPERATURE



COMMON-MODE REJECTION vs FREQUENCY



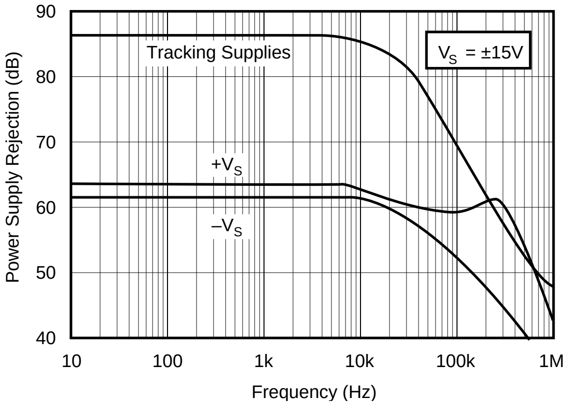
$I_B$– COMMON-MODE REJECTION RATIO



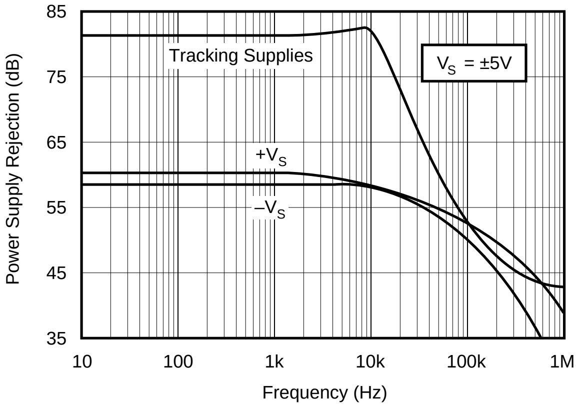
# TYPICAL PERFORMANCE CURVES (CONT)

At $T_A$ = +25°C, unless otherwise noted.

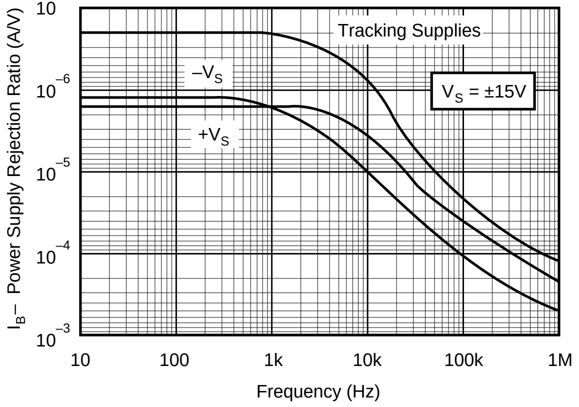
POWER SUPPLY REJECTION vs FREQUENCY



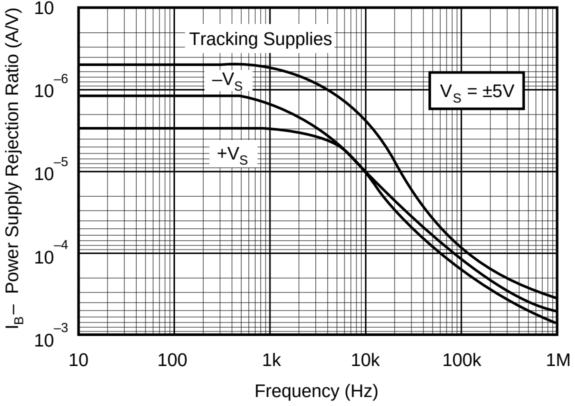
POWER SUPPLY REJECTION vs FREQUENCY



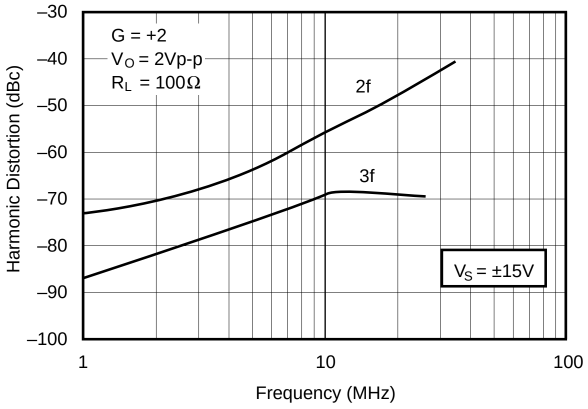
$I_B$– PSRR vs FREQUENCY



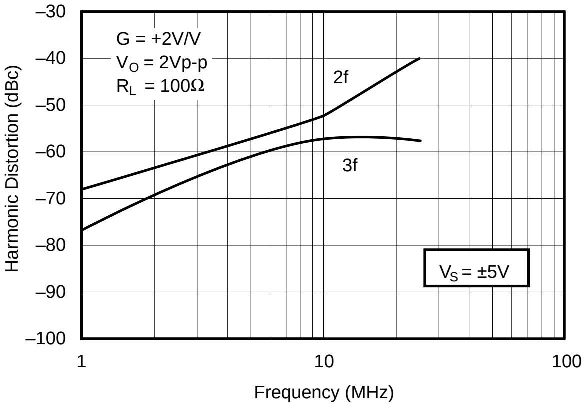
$I_B$– PSRR vs FREQUENCY



LARGE-SIGNAL
HARMONIC DISTORTION vs FREQUENCY



LARGE-SIGNAL
HARMONIC DISTORTION vs FREQUENCY



## TYPICAL PERFORMANCE CURVES (CONT)

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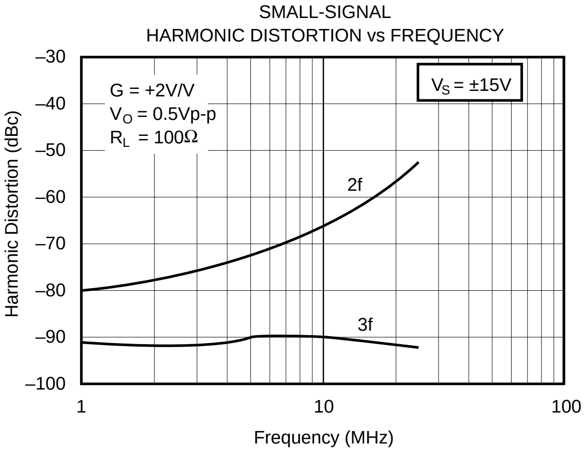
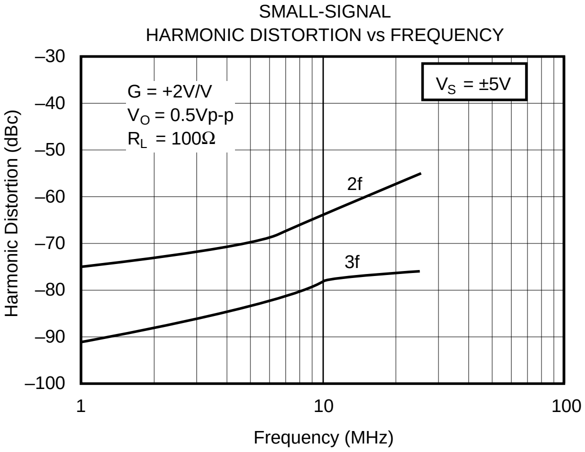
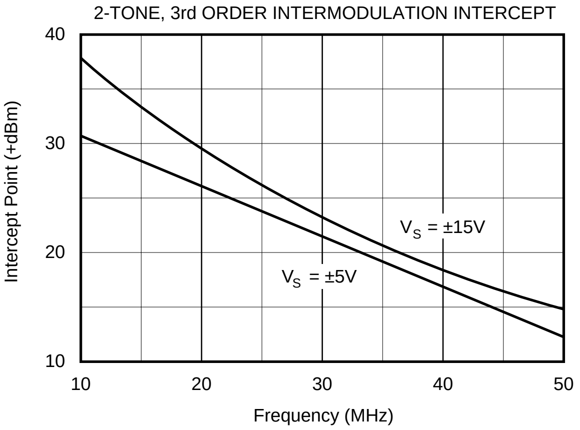
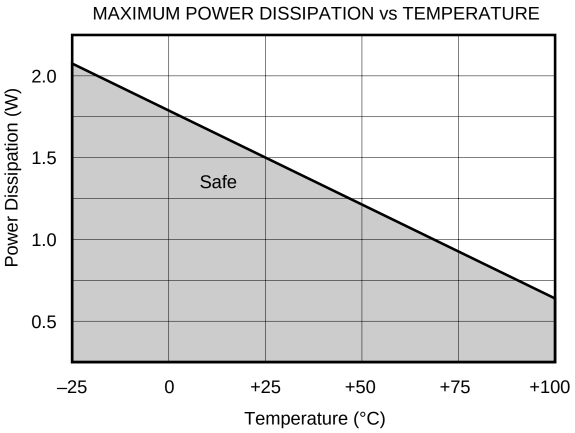
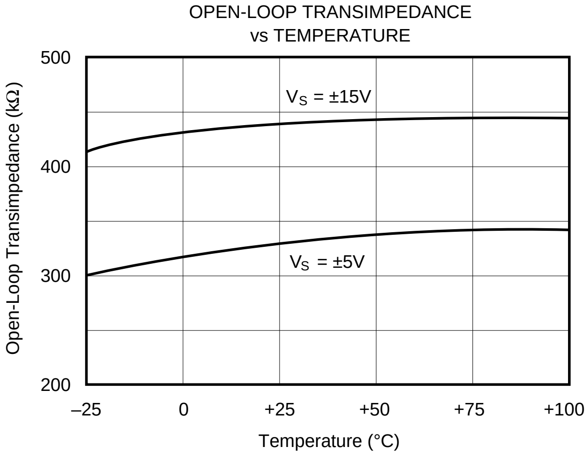
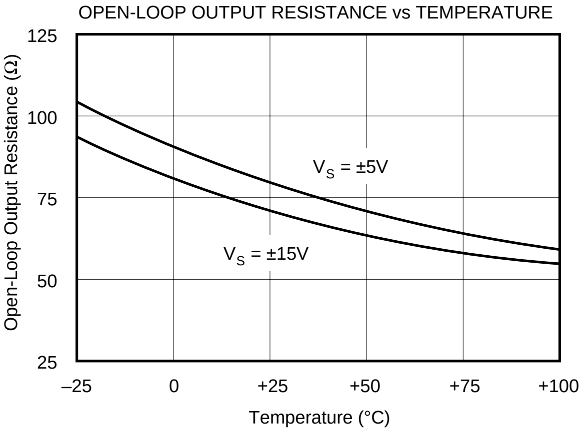






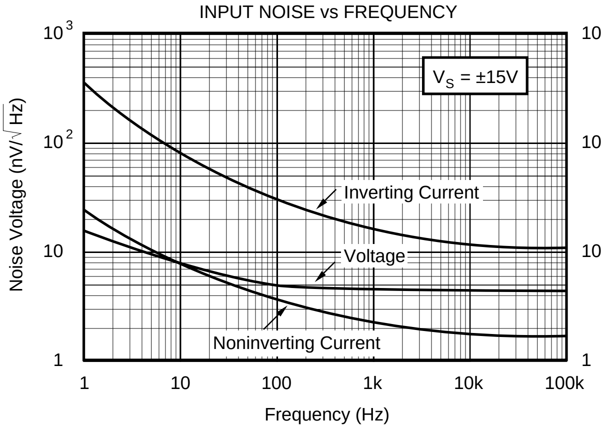


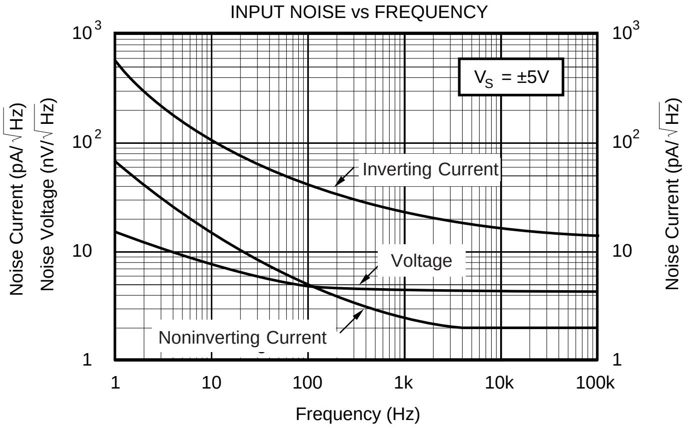


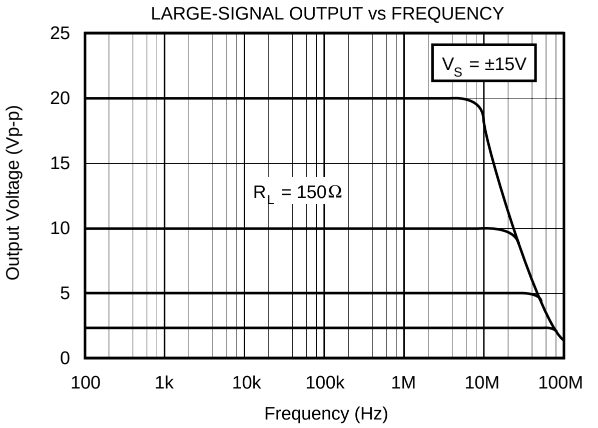


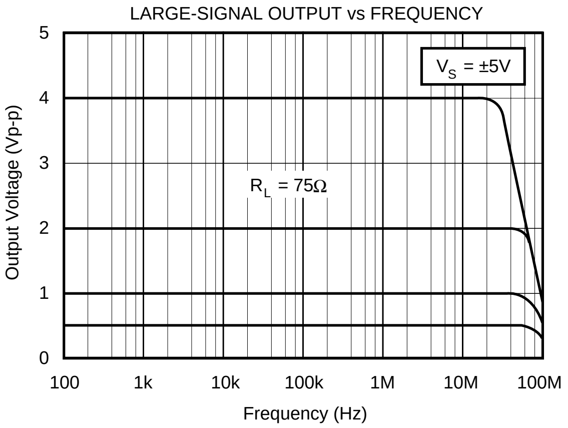
# TYPICAL PERFORMANCE CURVES (CONT)

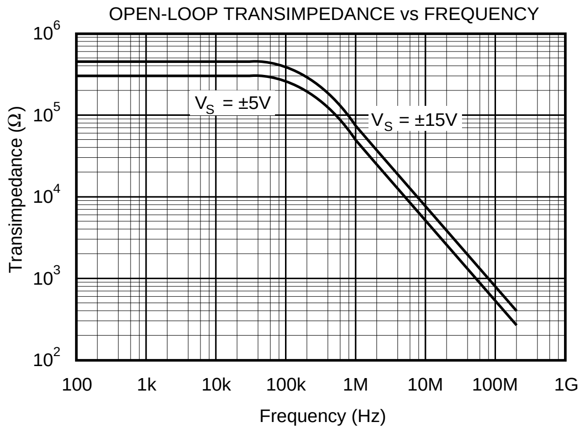
At $T_A$ = +25°C, unless otherwise noted.

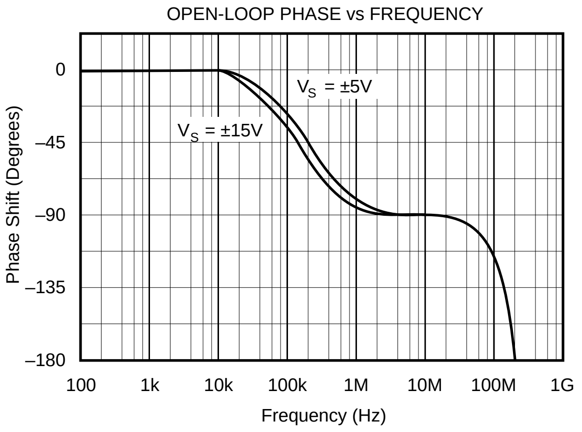

INPUT NOISE vs FREQUENCY


INPUT NOISE vs FREQUENCY


LARGE-SIGNAL OUTPUT vs FREQUENCY

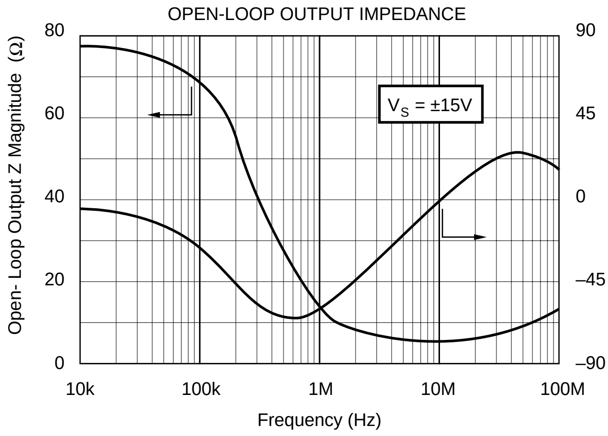

LARGE-SIGNAL OUTPUT vs FREQUENCY

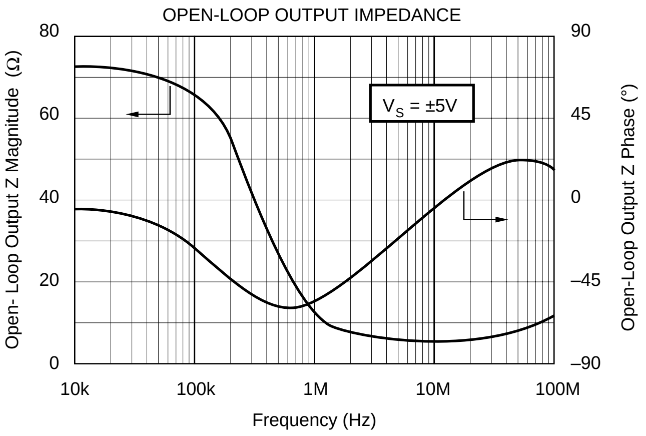

OPEN-LOOP TRANSIMPEDANCE vs FREQUENCY

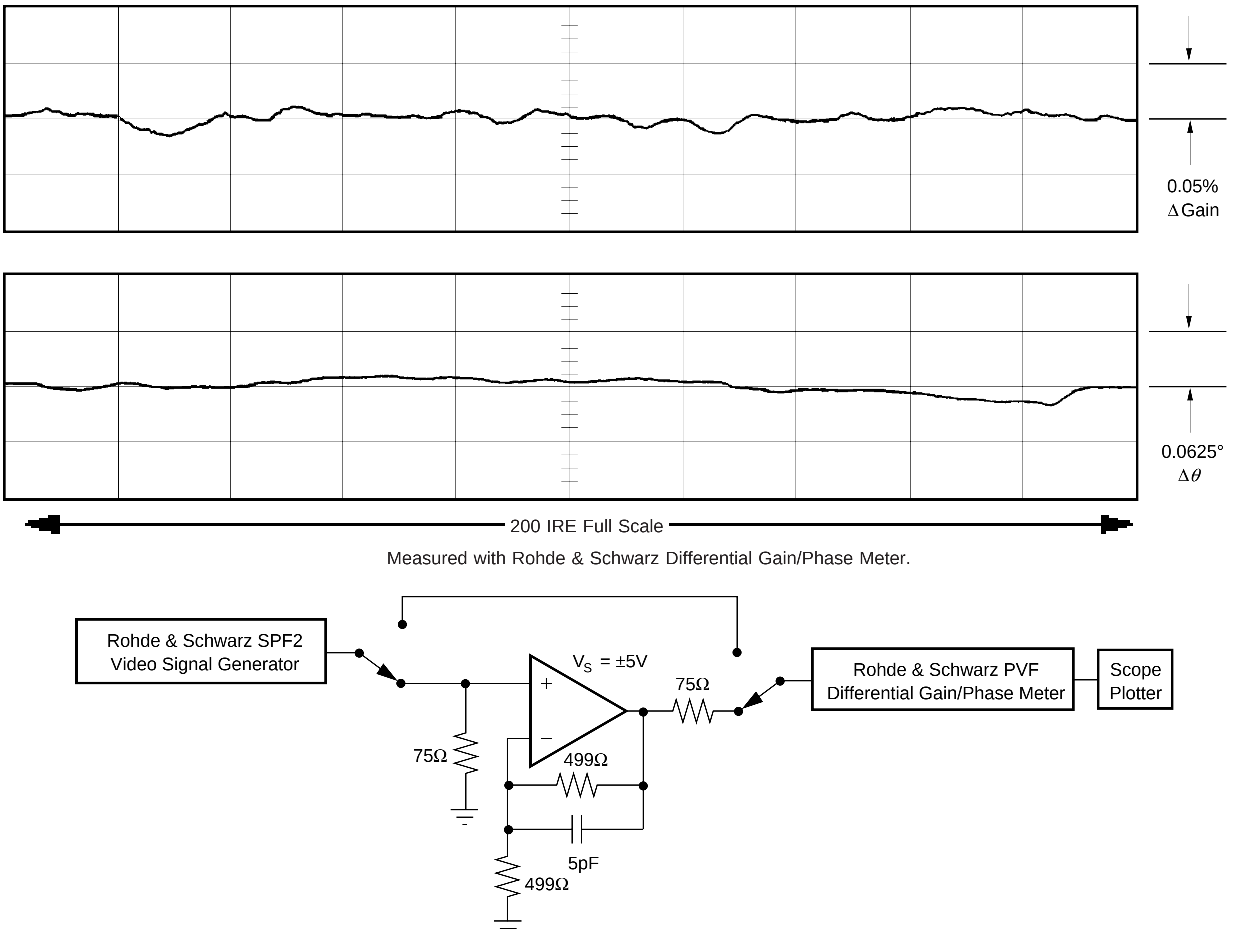

OPEN-LOOP PHASE vs FREQUENCY

# TYPICAL PERFORMANCE CURVES (CONT)

At $T_A$ = +25°C, unless otherwise noted.







Measured with Rohde & Schwarz Differential Gain/Phase Meter.

FIGURE 1. Video Differential Gain/Phase Performance.

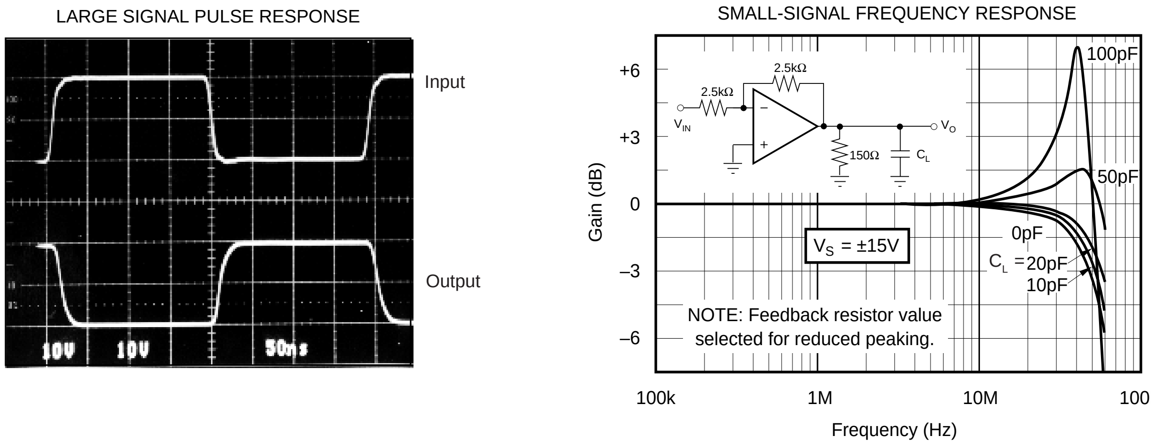


FIGURE 2. Dynamic Response, Inverting Unity-Gain.

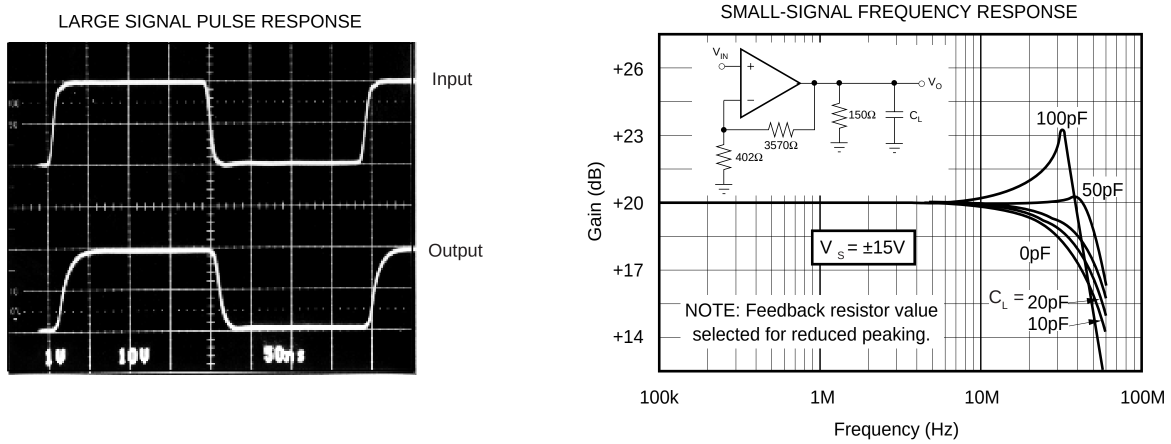


FIGURE 3. Dynamic Response, Gain = +10.

# APPLICATIONS INFORMATION

For most circuit configurations, the OPA603 current-feedback op amp can be treated like a conventional op amp. As with a conventional op amp, the feedback network connected to the inverting input controls the closed-loop gain. But with a current-feedback op amp, the impedance of the feedback network also controls the open-loop gain and frequency response.

Feedback resistor values can be selected to provide a nearly constant closed-loop bandwidth over a very wide range of gain. This is in contrast to a conventional op amp where circuit bandwidth is inversely proportional to the closed-loop gain, sharply limiting bandwidth at high gain.

Figures 4a and 4b show appropriate feedback resistor values versus closed-loop gain for maximum bandwidth with minimal peaking. The dual vertical axes of these curves also show the resulting bandwidth. Note that the bandwidth remains nearly constant as gain is increased.

With control of the open-loop characteristics of the op amp, dynamic behavior can be tailored to an application's requirements. Lower feedback resistance gives wider bandwidth, more frequency-response peaking and more pulse response overshoot. The higher open-loop gain resulting from lower feedback network resistors also yields lower distortion. Higher feedback network resistance gives an over-damped response with little or no peaking and overshoot. This may be beneficial when driving capacitive loads. Feedback network impedance can also be varied to optimize dynamic performance. To achieve wider bandwidth, use a feedback resistor value somewhat lower than indicated in Figure 4.

### EXTENDING BANDWIDTH

For gains less than approximately 20, bandwidth can be extended by adding a capacitor, $C_F$, in parallel with a lower value for $R_F$. The optimum feedback resistor value in this case is far lower than those shown in Figure 1. For ±15V operation, select $R_F$ with the following equation:

$$R_F\ (\Omega) = 30 \bullet (30 - G) \quad \text{for } V_S = \pm15V$$

For example, for a gain of 10, use $R_F$ = 600Ω. Optimum values differ slightly for ±5V operation:

$$R_F\ (\Omega) = 30 \bullet (23 - G) \quad \text{for } V_S = \pm5V$$

$C_F$ will range from 1pF to 10pF depending on the selected gain, load, and circuit layout. Adjust $C_F$ to optimize bandwidth and minimize peaking. Figure 5 shows bandwidth which can be acheived using this technique.

Typical values for this capacitor range from 1pF to 10pF depending on closed-loop gain and load characteristics. Too large a value of $C_F$ can cause instability.

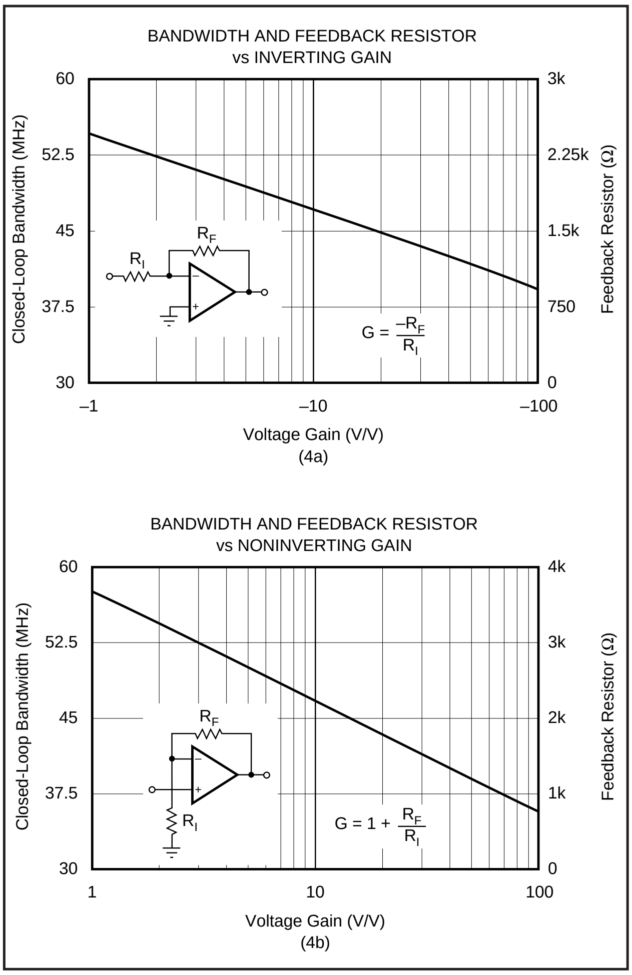


FIGURE 4. Feedback Resistor Selection Curves.

## UNITY-GAIN OPERATION

As Figure 4b indicates, the OPA603 can be operated in unity gain. A feedback resistor (approximately 2.8kΩ) sets the appropriate open-loop characteristics and resistor $R_I$ is omitted. Just as with gains greater than one, the value of the feedback resistor (and capacitor if used) can be optimized for the desired dynamic response and load characteristics.

Care should be exercised not to exceed the maximum differential input voltage rating of ±6V. Large input voltage steps which exceed the device's slew rate of 1000V/µs can apply excessive differential input voltage.

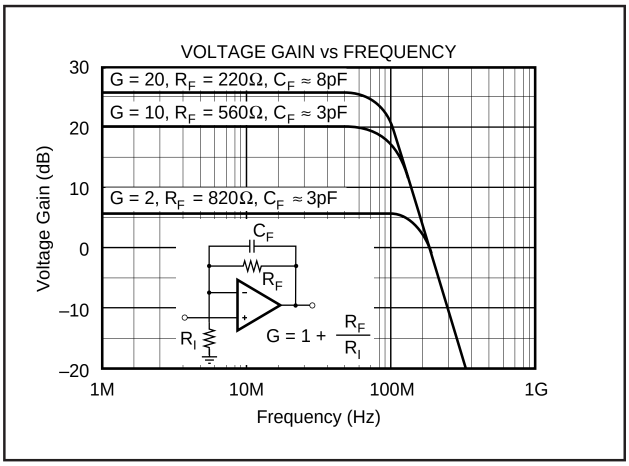


FIGURE 5. Bandwidth Results with Added Capacitor $C_F$.

## CIRCUIT LAYOUT

With any high-speed, wide-bandwidth circuitry, careful circuit layout will ensure best performance. Make short, direct circuit interconnections and avoid stray wiring capacitance—especially at the inverting input pin. A component-side ground plane will help ensure low ground impedance. Do not place the ground plane under or near the inputs and feedback network.

Power supplies should be bypassed with good high-frequency capacitors positioned close to the op amp pins. In most cases, a 0.01µF ceramic capacitor in parallel with a 2.2µF solid tantalum capacitor at each power supply pin is adequate. The OPA603 can deliver high load current—up to 150mA peak. Applications with low impedance or capacitive loads demand large current transients from the power supplies. It is the power supply bypass capacitors which must supply these current transients. Larger bypass capacitors such as 10µF solid tantalum capacitors may improve performance in these applications.

## POWER DISSIPATION

High output current causes increased internal power dissipation in the OPA603. Copper leadframe construction maximizes heat dissipation compared to conventional plastic packages. To achieve best heat dissipation, solder the device directly to the circuit board and use wide circuit board traces. Solder the unused pins, (1, 5 and 8) to a top-side ground plane for improved power dissipation. Limit the load and signal conditions depending on maximum ambient temperature to assure operation within the power derating curve.

The OPA603 may be operated at reduced power supply voltage to minimize power dissipation. Detailed specifications are provided for both ±15V and ±5V operation.

# APPLICATIONS CIRCUITS

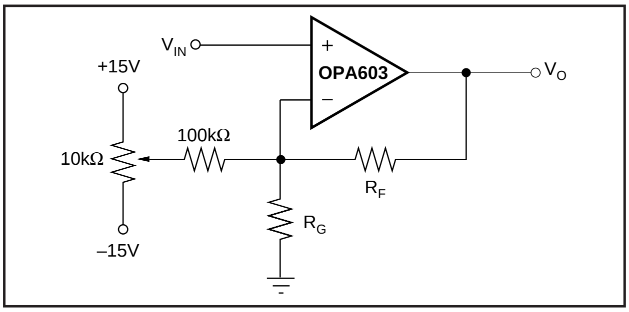


FIGURE 6. Offset Voltage Adjustment.

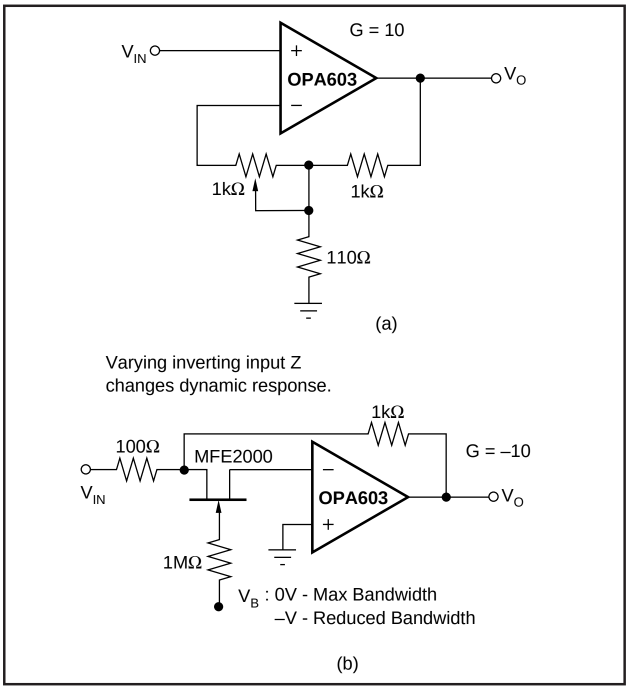


FIGURE 7. Controlling Dynamic Performance.

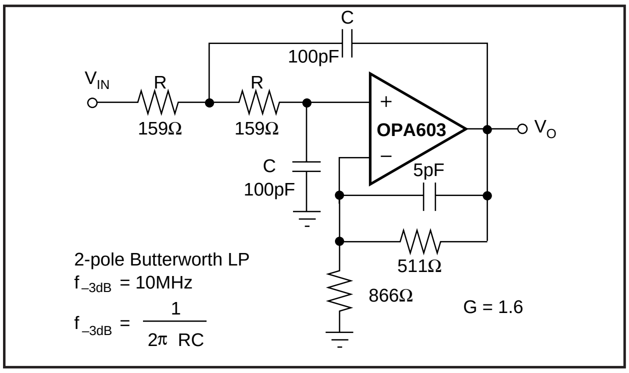


FIGURE 8. Low-Pass Filter — 10MHz.

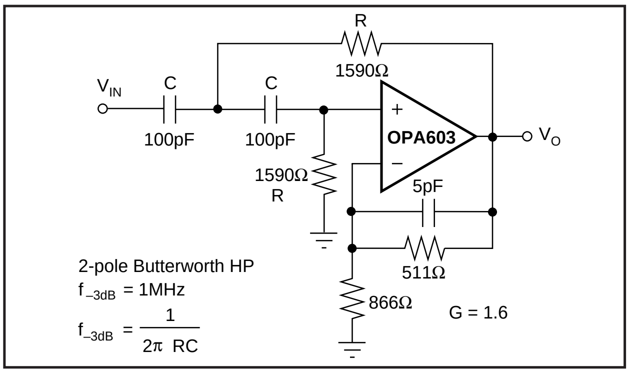


FIGURE 9. High-Pass Filter — 1MHz.

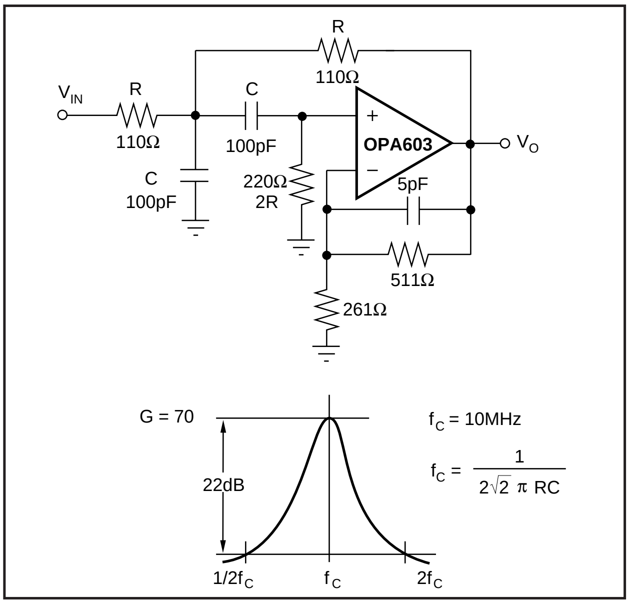
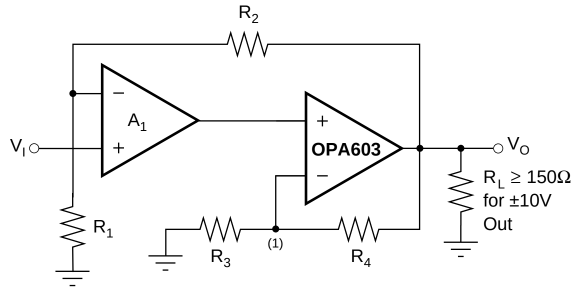


FIGURE 10. Bandpass Filter — 10MHz.



This composite amplifier uses the OPA603 current-feedback op amp to provide extended bandwidth and slew rate at high closed-loop gain. The feedback loop is closed around the composite amp, preserving the precision input characteristics of the OPA627/637. Use separate power supply bypass capacitors for each op amp. See Application Bulletin AB-007 for details.

NOTE: (1) Minimize capacitance at this node.

| GAIN (V/V) | $A_1$ OP AMP | $R_1$ (Ω) | $R_2$ (kΩ) | $R_3$ (Ω) | $R_4$ (kΩ) | –3dB (MHz) | SLEW RATE (V/µs) |
|---|---|---|---|---|---|---|---|
| 100 | OPA627 | 50.5[1] | 4.99 | 20 | 1 | 15 | 700 |
| 1000 | OPA637 | 49.9 | 4.99 | 12 | 1 | 11 | 500 |

NOTE: (1) Closest 1/2% value.

FIGURE 11. Precision-Input Composite Amplifier.