

OPA622

Wide-Bandwidth OPERATIONAL AMPLIFIER

FEATURES

- **LARGE SIGNAL BANDWIDTH:** 150MHz (AP), 200MHz (AU) (Voltage-Feedback)
- **HIGH OUTPUT CURRENT:** $\pm 70\text{mA}$
- **SLEW RATE:** 1500V/ μs (AP), 1700V/ μs (AU)
- **DIFFERENTIAL GAIN:** 0.15%
- **DIFFERENTIAL PHASE:** 0.08°
- **EXCELLENT BANDWIDTH/SUPPLY CURRENT RATIO:** 200MHz/5mA
- **LOW INPUT BIAS CURRENT:** $-1.2\mu\text{A}$

APPLICATIONS

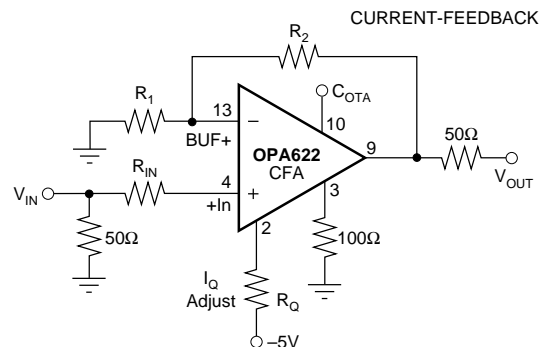
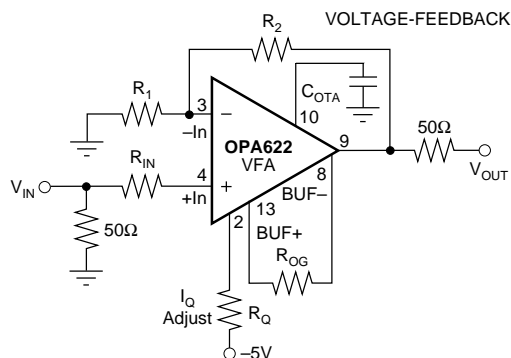
- **BROADCAST/HDTV EQUIPMENT**
- **COMMUNICATIONS**
- **PULSE/RF AMPLIFIERS**
- **ACTIVE FILTER**
- **HIGH SPEED ANALOG SIGNAL PROCESSING**
- **MULTIPLIER OUTPUT AMP**
- **DIFFERENTIATOR FOR DIGITIZED VIDEO SIGNALS**

DESCRIPTION

The OPA622 is a monolithic amplifier component designed for precision wide-bandwidth systems including high-resolution video, RF and IF circuitry, and communications equipment. It includes a monolithic integrated current-feedback operational amplifier block and a voltage buffer block, which, when combined, form a voltage-feedback operational amplifier.

When combined as a current-feedback amplifier, it provides a 280MHz large-signal bandwidth at $\pm 2.5\text{V}$ output level and a 1700V/ μs slew rate. The output buffer stage can deliver $\pm 70\text{mA}$ output current. The high output current capability allows the OPA622 to drive two 50 Ω or 75 Ω lines with $\pm 3\text{V}$ output swing, making it ideal along with the low differential gain/phase errors for RF, IF, and video applications.

The feedback buffer stage provides 700MHz bandwidth, a very high slew rate, and a very short signal delay time. It is designed primarily for interstage buffering and not for driving long cables. When combined with the current-feedback amplifier section, the OPA622 can be interconnected as a voltage-feedback amplifier with two identical high-impedance inputs. In this configuration, it features a low common-mode gain, low input offset, and, due to the delay time of the additional feedback buffer, a decrease in frequency bandwidth compared with the current-feedback configuration. Unlike "classical" operational amplifiers, the OPA622 achieves a nearly constant bandwidth over a wide gain and output voltage range. The external setting of the open-loop gain with R_{OG} avoids a large compensation capacitor, improves the slew rate, and allows a frequency response adaption to various gains and load conditions.



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

SPECIFICATIONS

DC-SPECIFICATION

VOLTAGE-FEEDBACK AMPLIFIER (Figure 5)

At $V_{CC} = \pm 5V$, $I_Q = \pm 5mA$, $G_{CL} = +2V/V$, $R_{LOAD} = 100\Omega$, $R_{SOURCE} = 50\Omega$, $R_Q = 430\Omega$, $R_{OG} = 150\Omega$ and $T_A = +25^\circ C$, unless otherwise specified.

PARAMETER	CONDITIONS	OPA622AP, AU			UNITS
		MIN	TYP	MAX	
CLOSED-LOOP OUTPUT OFFSET VOLTAGE Initial vs Temperature vs Supply (tracking) vs Supply (non-tracking) vs Supply (non-tracking)	$V_{CC} = \pm 4.5V$ to $\pm 5.5V$ $V_{CC} = +4.5V$ to $+5.5V$ $V_{CC} = -4.5V$ to $-5.5V$	-46	1 210 -50 -43 -51	± 15	mV $\mu V/^\circ C$ dB dB dB
INPUT BIAS CURRENT Initial vs Temperature vs Supply (tracking) vs Supply (non-tracking) vs Supply (non-tracking)	$V_{CC} = \pm 4.5V$ to $\pm 5.5V$ $V_{CC} = +4.5V$ to $+5.5V$ $V_{CC} = -4.5V$ to $-5.5V$		-1.2 7 29 170 58	± 4	μA $nA/^\circ C$ nA/V nA/V nA/V
OFFSET CURRENT Input Offset Current	$V_{CM} = 0V$		0.1		μA
INPUT IMPEDANCE Differential Mode			$2.4 \parallel 1$		$M\Omega \parallel pF$
INPUT NOISE Voltage Noise Density Signal-to-Noise Ratio	$f = 100kHz$ to $100MHz$ $S/N = 20 \log 0.7/(V_N \cdot \sqrt{5MHz})$		11 89		nV/\sqrt{MHz} dB
INPUT VOLTAGE RANGE Common-Mode Input Range Common-Mode Rejection	$V_I = +2.5V$, $V_O = 0V$		± 3.2 78		V dB
RATED OUTPUT Voltage Output Closed-Loop Output Impedance Current Output	$G_{CL} = +1$	± 3	± 3.2 0.2 70		V Ω mA
POWER SUPPLY Rated Voltage Derated Performance Quiescent Current Quiescent Current (programmable)	$R_Q = 430\Omega$, $I_O = 0mA$ Useful Range, $I_O = 0mA$	± 4.5 ± 4.4	± 5 ± 5 3 to 8	± 5.5 ± 5.6	V V mA mA
TEMPERATURE Operating Storage	Ambient Temperature Ambient Temperature	-40 -40		85 125	$^\circ C$ $^\circ C$

ABSOLUTE MAXIMUM RATINGS

Power Supply Voltage	$\pm 6V$
Input Voltage ⁽¹⁾	$\pm V_{CC}$ to $\pm 0.7V$
Operating Temperature	$-40^\circ C$ to $+85^\circ C$
Storage Temperature	$-40^\circ C$ to $+125^\circ C$
Junction Temperature	$+150^\circ C$
Lead Temperature (soldering, 10s)	$+300^\circ C$

NOTE: (1) Inputs are internally diode-clamped to $\pm V_{CC}$.

PACKAGE INFORMATION

MODEL	DESCRIPTION	PACKAGE DRAWING NUMBER ⁽¹⁾
OPA622AP	14-Pin Plastic DIP	010
OPA622AU	SO-14 Surface-Mount	235

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

ORDERING INFORMATION

MODEL	DESCRIPTION	TEMPERATURE RANGE
OPA622AP	14-Pin Plastic DIP	$-40^\circ C$ to $+85^\circ C$
OPA622AU	SO-14 Surface-Mount	$-40^\circ C$ to $+85^\circ C$

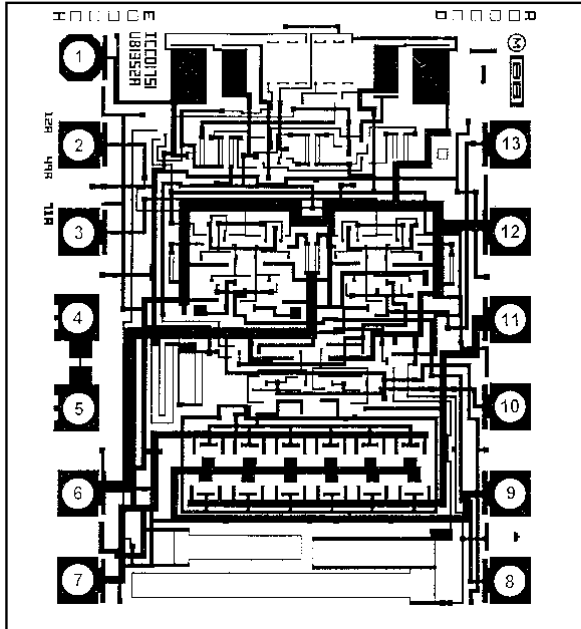
The information provided herein is believed to be reliable; however, BURR-BROWN assumes no responsibility for inaccuracies or omissions. BURR-BROWN assumes no responsibility for the use of this information, and all use of such information shall be entirely at the user's own risk. Prices and specifications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

AC-SPECIFICATION VOLTAGE-FEEDBACK AMPLIFIER (Figure 5)

At $V_{CC} = \pm 5V$, $I_Q = \pm 5mA$, $G_{CL} = +2V/V$, $R_{LOAD} = 100\Omega$, $R_{SOURCE} = 50\Omega$, $R_Q = 430\Omega$, $R_{OG} = 150\Omega$ and $T_A = +25^\circ C$, unless otherwise specified.

PARAMETER	CONDITIONS	OPA622AP	OPA622AU	UNITS
		TYP	TYP	
FREQUENCY DOMAIN				
LARGE SIGNAL Closed-Loop Bandwidth (-3dB)	$V_O = 2.8Vp-p$, Gain = +1V/V	220	250	MHz
	$V_O = 2.8Vp-p$, Gain = +2V/V	200	250	MHz
	$V_O = 2.8Vp-p$, Gain = +5V/V	170	230	MHz
	$V_O = 2.8Vp-p$, Gain = +10V/V	110	110	MHz
	$V_O = 2.8Vp-p$, Gain = -1V/V	150	250	MHz
	$V_O = 2.8Vp-p$, Gain = -2V/V	160	250	MHz
	$V_O = 5.0Vp-p$, Gain = +2V/V	150	200	MHz
SMALL SIGNAL BANDWIDTH	$V_O = 0.2Vp-p$, Gain = +2V/V	150	170	MHz
GROUP DELAY TIME		1.4	1.4	ns
DIFFERENTIAL GAIN	$f = 4.43MHz$, $R_{LOAD} = 150\Omega$			
	$V_O = 0.7V$, Gain = +1V/V	0.12	0.12	%
	$V_O = +1.4V$, Gain = +2V/V	0.15	0.15	%
DIFFERENTIAL PHASE	$f = 4.43MHz$, $R_{LOAD} = 150\Omega$			
	$V_O = 0.7V$, Gain = +1V/V	0.06	0.06	Degrees
	$V_O = +1.4V$, Gain = +2V/V	0.08	0.08	Degrees
HARMONIC DISTORTION	Gain = +2V/V			
	Second Harmonic 2f $f = 10MHz$, $V_O = 2.8Vp-p$	-57	-57	dBc
	Third Harmonic 3f	-55	-55	dBc
	Second Harmonic 2f $f = 30MHz$, $V_O = 2.8Vp-p$	-38	-38	dBc
	Third Harmonic 3f	-43	-43	dBc
	Second Harmonic 2f $f = 50MHz$, $V_O = 2.8Vp-p$	-33	-33	dBc
Third Harmonic 3f	-30	-30	dBc	
GAIN FLATNESS PEAKING	Gain = +2V/V			
	$V_O = 2.8Vp-p$, DC to 30MHz	0.12	0.12	dB
	$V_O = 2.8Vp-p$, DC to 100MHz	0.3	0.3	dB
TIME DOMAIN				
	Rise Time	Gain = +2V/V, 10% to 90% $V_O = 5Vp-p$, $C_L = 2pF$	2.4	2.7
Fall Time	Gain = +2V/V, 10% to 90% $V_O = 5Vp-p$, $C_L = 2pF$	3.5	3.2	ns
SLEW RATE	Gain = +2V/V, Rise Time = 2ns $V_O = 6.2Vp-p$			
	Positive	1500	1700	V/ μs
	Negative	1300	1600	V/ μs
SETTLING TIME	Gain = +2V/V, Rise Time = 2ns $V_O = 2Vp-p$, 0.1%	17	17	ns

DICE INFORMATION



OPA622AD DIE TOPOGRAPHY

PAD	FUNCTION
1	Quiescent Current Adjustment
2	Inverting Analog Input
3	Non-Inverting Analog Input
4	NC
5	NC
6	-5V Supply
7	-5V Supply, Output
8	Inverting Buffer Output
9	Analog Output
10	Analog OTA Output
11	+5V Supply, Output
12	+5V Supply
13	Non-Inverting Buffer Output

Substrate Bias: Negative Supply

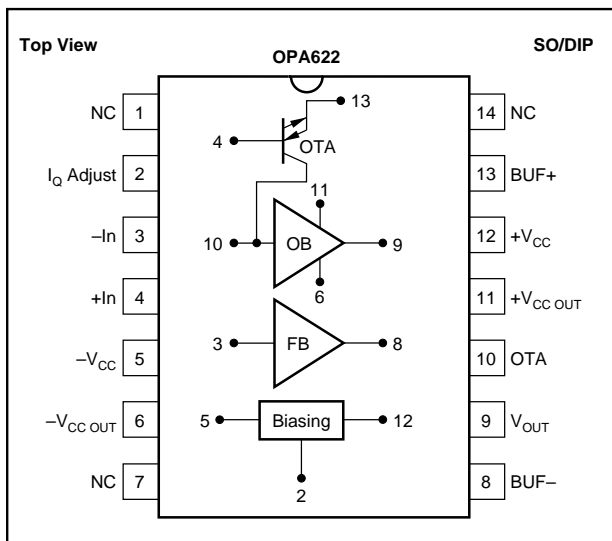
NC: No Connection

Wire Bonding: Gold wire bonding is recommended.

MECHANICAL INFORMATION

	MILS (0.001")	MILLIMETERS
Die Size	57 x 69 ±5	1.44 x 1.76 ±0.13
Die Thickness	14 ±1	0.55 ±0.025
Min. Pad Size	4 x 4	0.10 x 0.10
Backing: Titanium	0.02+0.05,-0.0	0.0005+0.0013, -0.0
Gold	0.30 ±0.05	0.0076 ±0.0013

PIN CONFIGURATION



FUNCTIONAL DESCRIPTION

PIN NO.	DESCRIPTION	FUNCTION
1	NC	No Connection
2	I_Q Adjust	Quiescent Current Adjustment; typical 3-8mA
3	-In	Inverting Analog Input
4	+In	Noninverting Analog Input
5	$-V_{CC}$	Negative Supply Voltage; typical -5VDC
6	$-V_{CC OUT}$	Negative Supply Voltage Output Buffer; typical -5VDC
8	BUF-	Analog Output Feedback Buffer
9	V_{OUT}	Analog Output
10	OTA	Analog Output OTA
11	$+V_{CC OUT}$	Positive Supply Voltage Output Buffer; typical +5VDC
12	$+V_{CC}$	Positive Supply Voltage; typical +5VDC
13	BUF+	Analog Output/Input
14	NC	No Connection



ELECTROSTATIC DISCHARGE SENSITIVITY

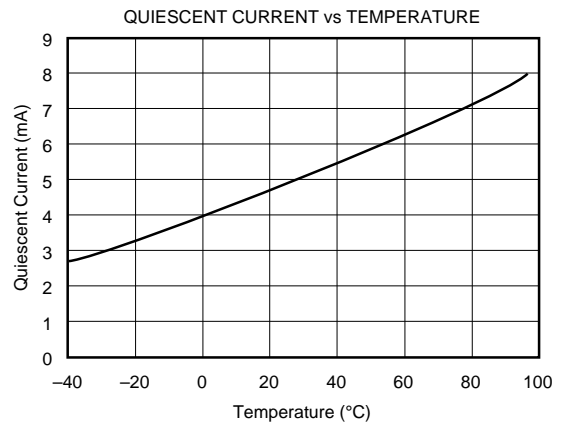
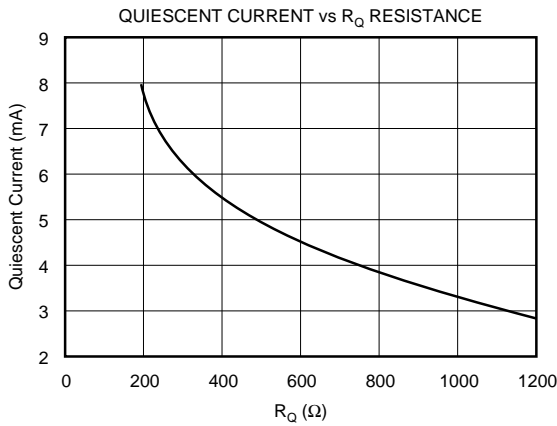
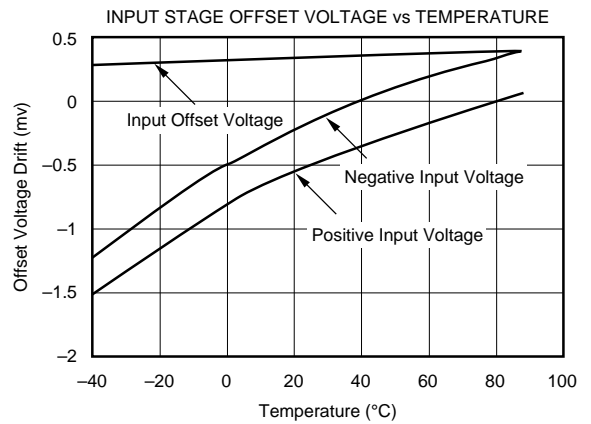
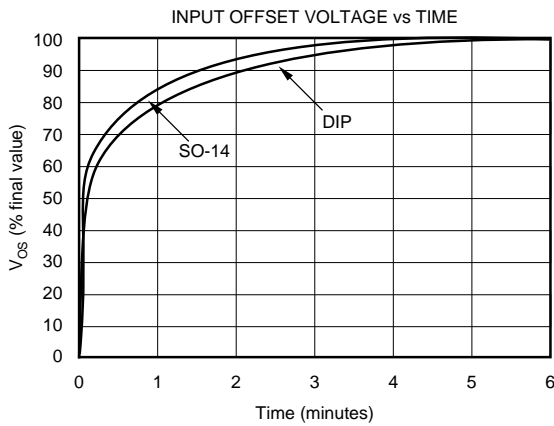
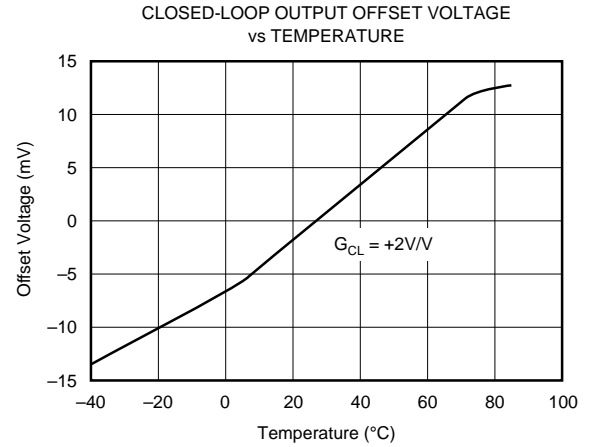
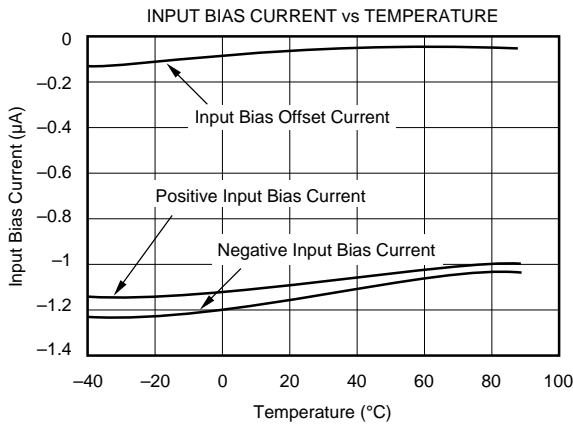
Electrostatic discharge can cause damage ranging from performance degradation to complete device failure. Burr-Brown Corporation recommends that all integrated circuits be handled and stored using appropriate ESD protection methods.

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

TYPICAL PERFORMANCE CURVES

VOLTAGE-FEEDBACK AMPLIFIER (Figure 5)

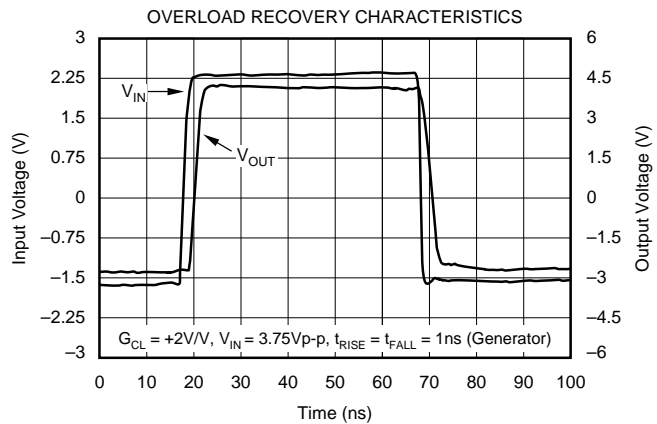
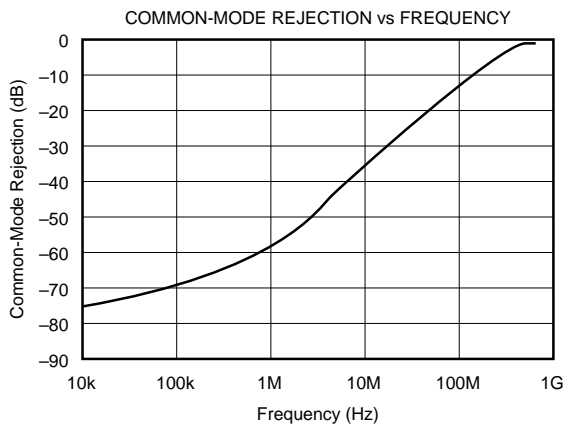
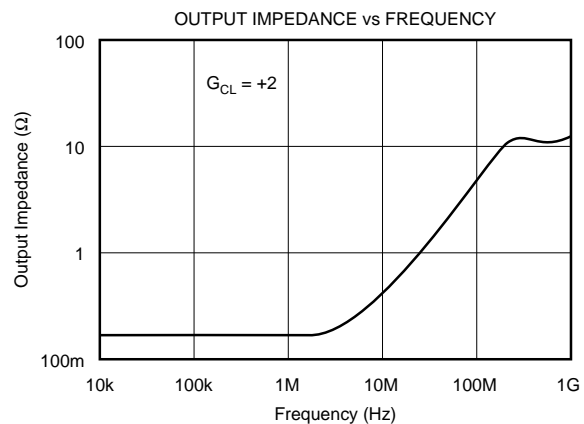
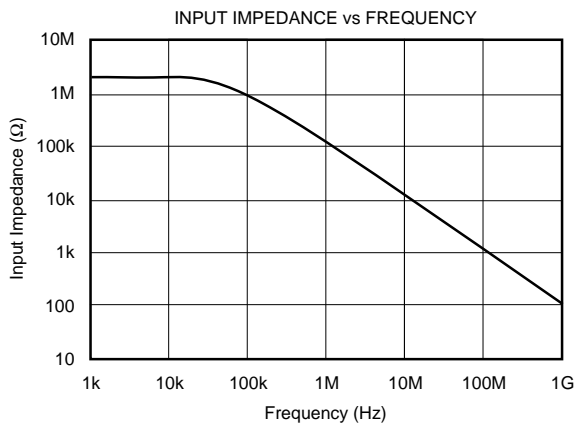
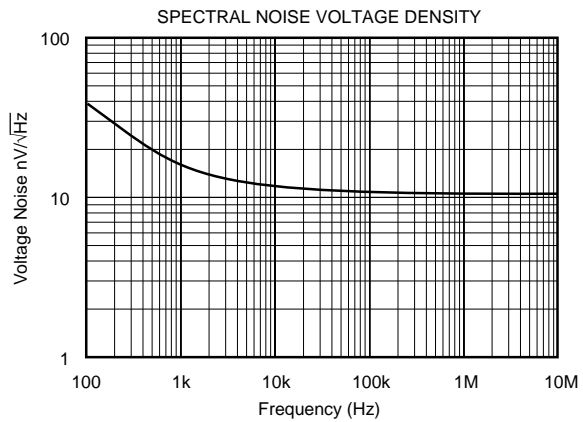
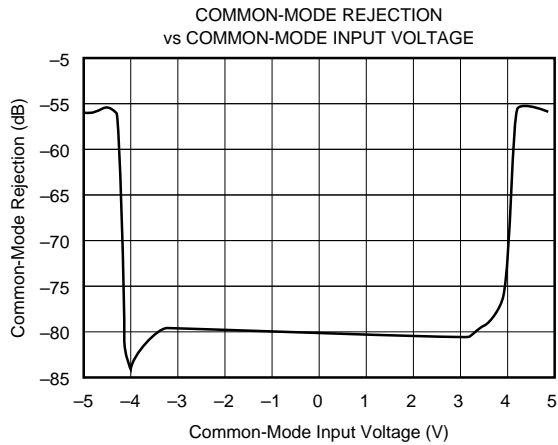
At $V_{CC} = \pm 5V$, $I_Q = \pm 5mA$, $G_{CL} = +2V/V$, $R_{LOAD} = 100\Omega$, $R_{SOURCE} = 50\Omega$, $R_Q = 430\Omega$, $R_{OG} = 150\Omega$ and $T_A = +25^\circ C$, unless otherwise specified.



TYPICAL PERFORMANCE CURVES (CONT)

VOLTAGE-FEEDBACK AMPLIFIER (Figure 5)

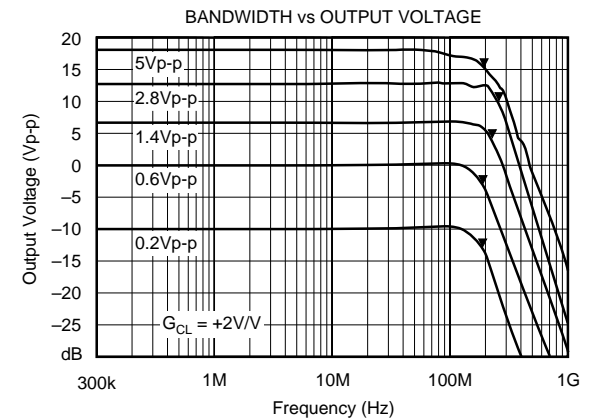
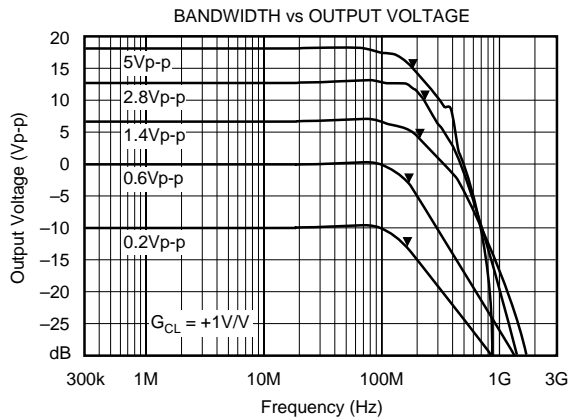
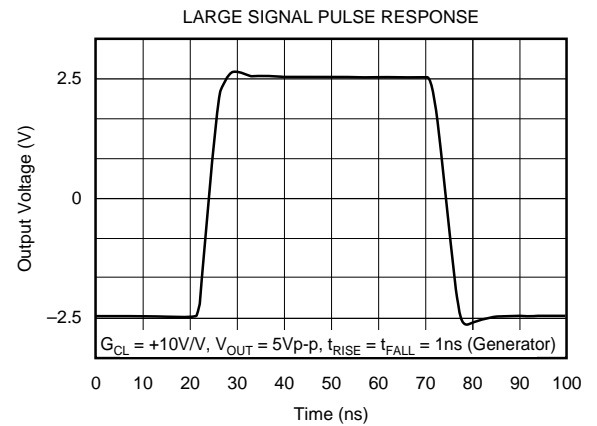
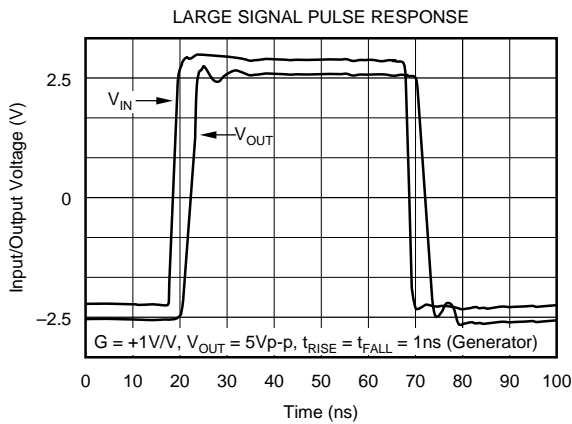
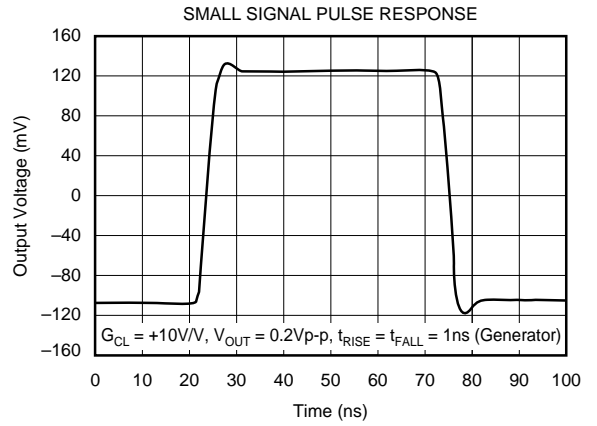
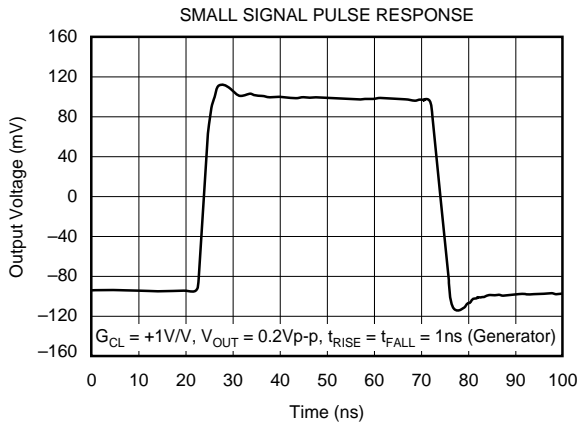
At $V_{CC} = \pm 5V$, $I_Q = \pm 5mA$, $G_{CL} = +2V/V$, $R_{LOAD} = 100\Omega$, $R_{SOURCE} = 50\Omega$, $R_Q = 430\Omega$, $R_{OG} = 150\Omega$ and $T_A = +25^\circ C$, unless otherwise specified.



TYPICAL PERFORMANCE CURVES (CONT)

VOLTAGE-FEEDBACK AMPLIFIER (Figure 5)

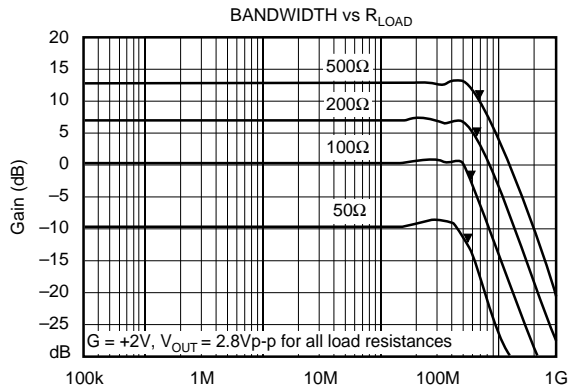
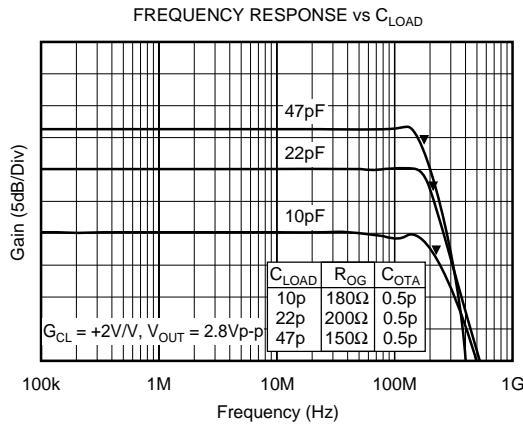
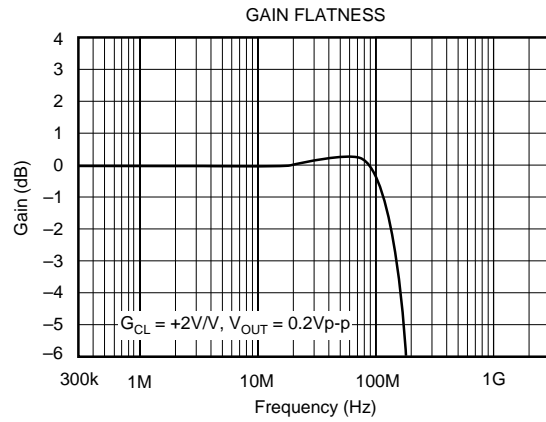
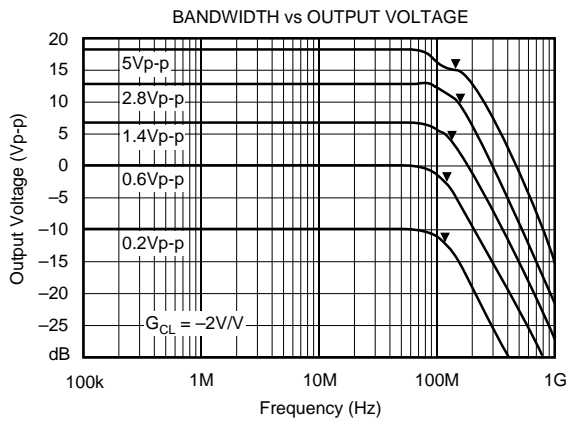
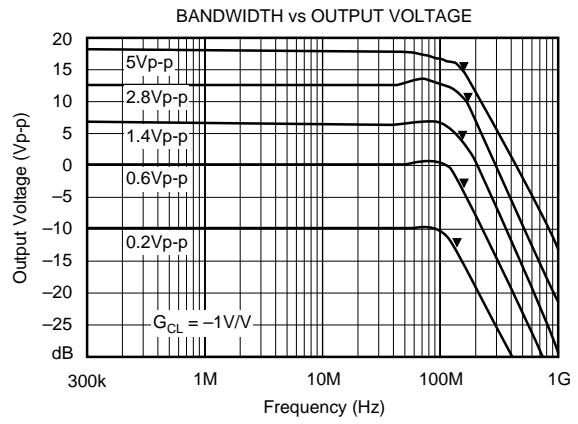
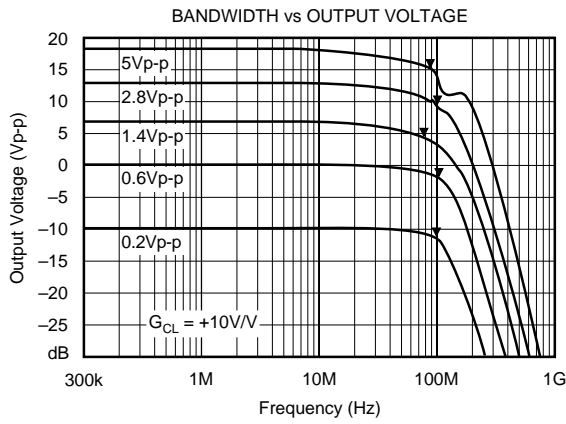
At $V_{CC} = \pm 5V$, $I_Q = \pm 5mA$, $G_{CL} = +2V/V$, $R_{LOAD} = 100\Omega$, $R_{SOURCE} = 50\Omega$, $R_Q = 430\Omega$, $R_{OG} = 150\Omega$ and $T_A = +25^\circ C$, unless otherwise specified.



TYPICAL PERFORMANCE CURVES (CONT)

VOLTAGE-FEEDBACK AMPLIFIER (Figure 5)

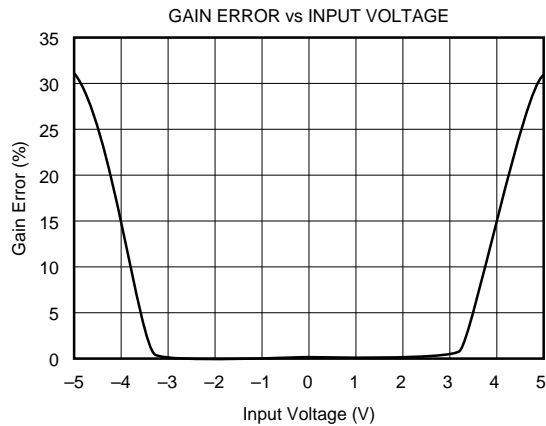
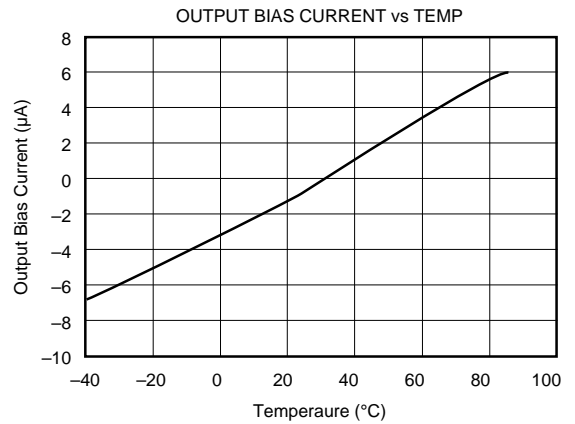
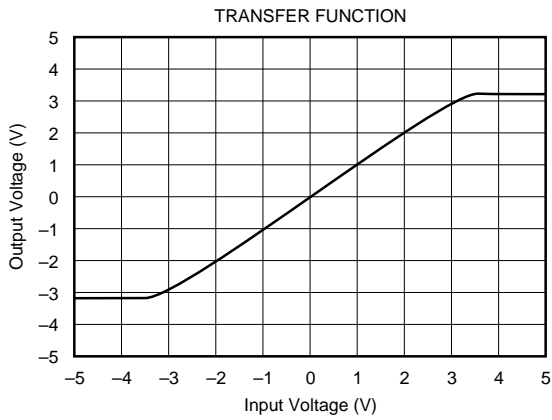
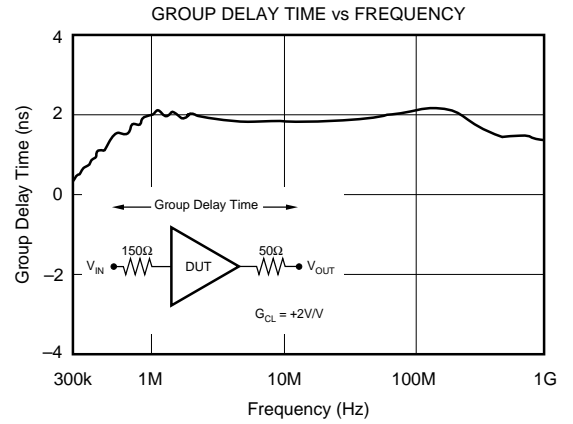
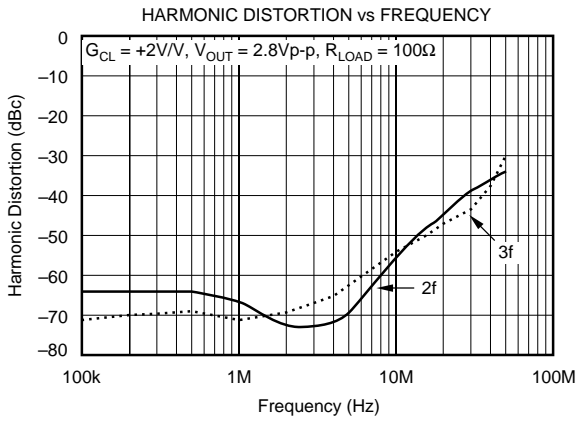
At $V_{CC} = \pm 5V$, $I_Q = \pm 5mA$, $G_{CL} = +2V/V$, $R_{LOAD} = 100\Omega$, $R_{SOURCE} = 50\Omega$, $R_Q = 430\Omega$, $R_{OG} = 150\Omega$ and $T_A = +25^\circ C$, unless otherwise specified.



TYPICAL PERFORMANCE CURVES (CONT)

VOLTAGE-FEEDBACK AMPLIFIER (Figure 5)

At $V_{CC} = \pm 5V$, $I_Q = \pm 5mA$, $G_{CL} = +2V/V$, $R_{LOAD} = 100\Omega$, $R_{SOURCE} = 50\Omega$, $R_Q = 430\Omega$, $R_{OG} = 150\Omega$ and $T_A = +25^\circ C$, unless otherwise specified.



INPUT PROTECTION

The need for protection from static damage has long been recognized for MOSFET devices, but all semiconductor devices deserve protection from this potentially damaging source. The OPA622 incorporates on-chip ESD protection diodes as shown in Figure 1. These diodes eliminate the need for external protection diodes, which can add capacitance and degrade AC performance.

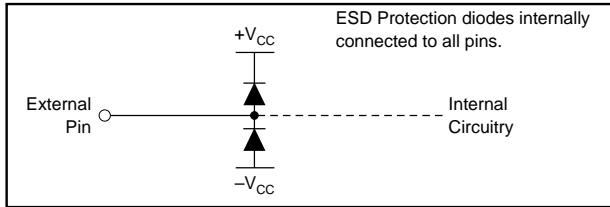


FIGURE 1. Internal ESD Protection.

As shown, all input pins of the OPA622 are protected from ESD internally by a pair of back-to-back reverse-biased diodes to either power supply. These diodes begin to conduct when the input voltage exceeds either power supply by about 0.7V. This situation can occur when the amplifier loses its power supplies while a signal source is still present. The diodes can typically withstand a continuous current of 30mA without destruction. To ensure long-term reliability, however, the diode current should be limited externally to approximately 10mA whenever possible.

The internal protection diodes are designed to withstand 2.5kV (using the Human Body Model) and will provide adequate ESD protection for most normal handling procedures. However, static damage can cause subtle changes in

the amplifier input characteristics without necessarily destroying the device. In precision amplifiers, such changes may degrade offset and drift noticeably. For this reason, static protection is strongly recommended when handling the OPA622.

DISCUSSION OF PERFORMANCE

The OPA622 provides full-power bandwidth previously unattainable in monolithic devices. In addition, the amplifier operates with reduced quiescent. The flexibility of the OPA622 design provides the speed advantages of a current-feedback amplifier or the precision advantages of a voltage-feedback amplifier. The programmable quiescent current feature also helps to adapt the amplifier to the particular design requirements.

Figure 2 shows the simplified circuit diagram of the OPA622. It contains four major sections: the bias circuitry, the OTA, the output buffer, and the feedback buffer.

BIAS CIRCUITRY

The bias circuitry controls the quiescent current of the signal processing stages, allows external quiescent current setting using the resistor R_Q connected from Pin 2 to $-V_{CC}$, sets the amplifier's transconductance, and, with its temperature characteristics, maintains a constant transconductance over temperature. The quiescent current controls the small-signal bandwidth and AC behavior. The OPA622 is specified with a quiescent current of $\pm 5\text{mA}$ with $R_Q = 430\Omega$. The recommended range is $\pm 3\text{mA}$ to $\pm 8\text{mA}$.

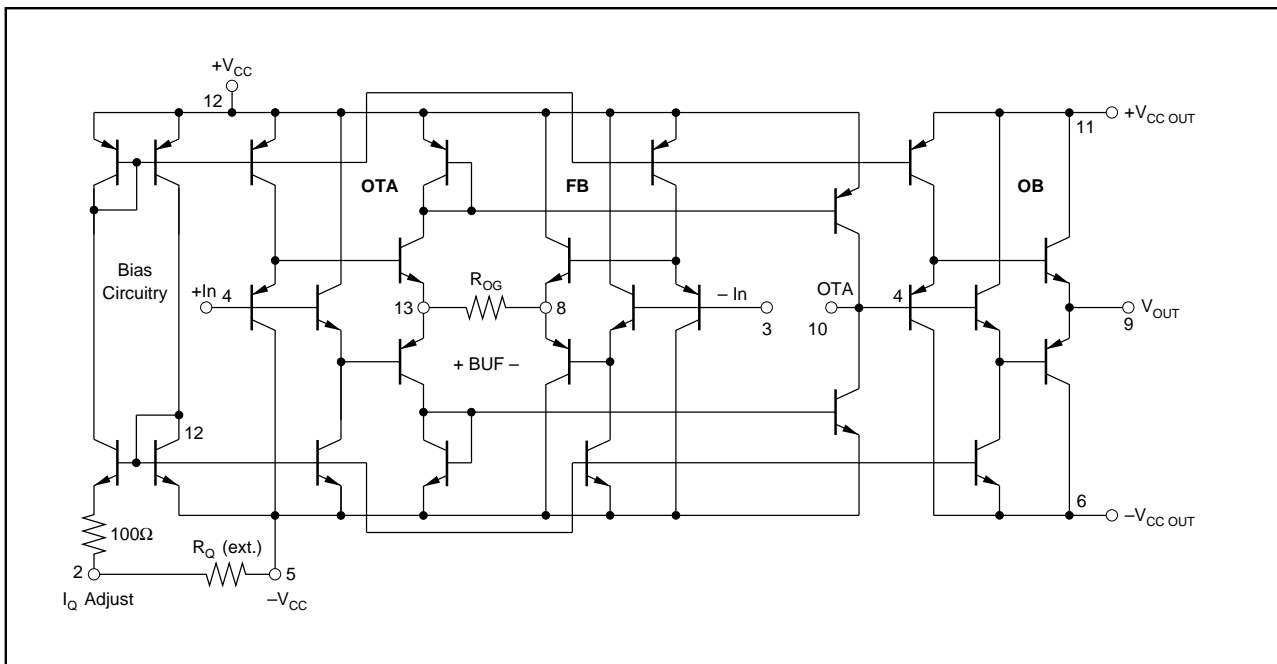


FIGURE 2. Simplified Circuit Diagram.

Application circuits generally do not show the resistor R_Q , but it is required for proper operation.

With a fixed R_Q , the quiescent current increases with temperature (see Typical Performance Curves.) This variation of the quiescent current with temperature keeps the bandwidth and AC behavior relatively constant with temperature. It is also possible to vary the quiescent current by an external control signal or circuitry. Figure 3 shows a circuit to disable the OPA622 with TTL-compatible logic levels. 0V/5V logic levels are converted into a 1mA/0mA current connected to Pin 2. The current flowing in R_Q increases the voltage at Pin 2 to approximately 1V above the $-V_{CC}$ rail, thus reducing I_Q to near zero and disabling the OPA622.

OTA AND OUTPUT BUFFER SECTIONS

An Operational Transconductance Amplifier (OTA) and an output buffer are the basic building blocks of a current-feedback amplifier. The current-feedback configuration of the OPA622 is illustrated in Figure 4. The OTA consists of a complementary emitter follower and a subsequent complementary current mirror. The voltage at the high-impedance +In terminal is transferred to the BUF+ input/output terminal at a low impedance. If a current flows into or out of the BUF+ terminal, the complementary mirror reflects the current to the OTA terminal. The current flow at the high-impedance OTA terminal is determined by the product of the voltage between the +In and BUF+ terminals and the transconductance. The output buffer section is an open-loop buffer consisting of complementary emitter followers. It is designed to drive cables or low-impedance loads. The buffer output is not current-limited or -protected. As can be seen in Figure 4, the feedback network for a current-feedback amplifier is applied between the V_{OUT} and BUF+ terminals. Figure 8 illustrates the bandwidth for various output voltages of the current feedback configuration.

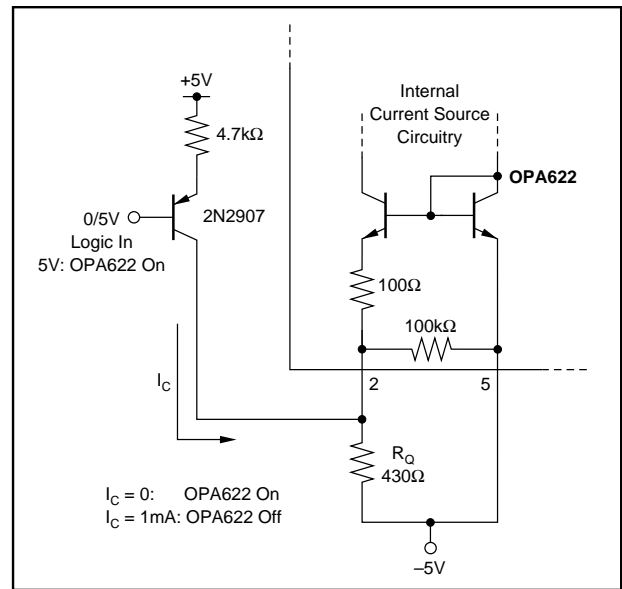


FIGURE 3. Logic-Controlled Disable Circuit.

FEEDBACK BUFFER SECTION

This section of the OPA622 is a complementary emitter follower identical to the input buffer of the OTA section. It is designed for interstage buffering, not for driving long cables or low-impedance loads. A minimum load resistance of 500Ω is recommended when using the feedback buffer as a stand-alone device. The feedback buffer output is not current-limited or -protected. The bandwidth of the feedback buffer is shown in Figure 7.

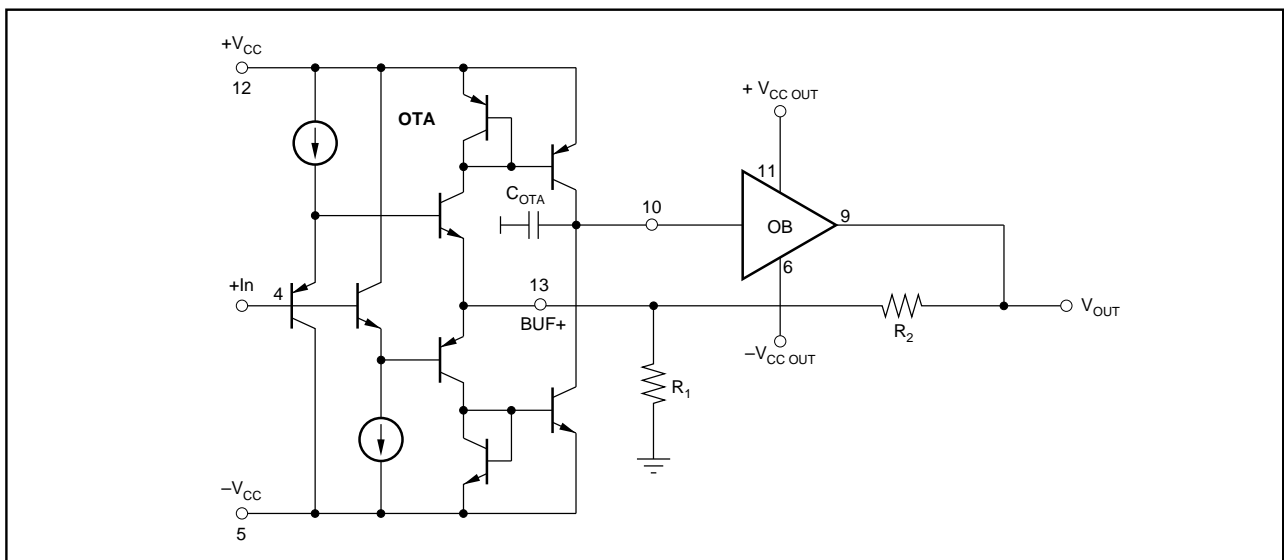


FIGURE 4. Current-Feedback Amplifier.

CONFIGURATIONS

VOLTAGE-FEEDBACK AMPLIFIER

The OPA622's internal design differs from a "classical" operational amplifier structure, but it can nevertheless be used in all traditional operational amplifier applications. As with conventional op amps, the feedback network connected to the inverting input controls closed-loop gain (G_{CL}). But with the OPA622, the resistor R_{OG} is simultaneously adapted to the closed-loop gain, optimizing the frequency response and stability.

The "classical" differential input stage consists of two identical transistors with an emitter degeneration resistor, two current sources, and an active load diode. However, the classical configuration limits the current through the gain transistor to that supplied by the current sources.

In the new design, a complementary push-pull buffer (emitter follower) replaces one side of the differential stage without the 0.7V offset. The feedback buffer as a second complementary emitter follower and the open-loop gain resistor R_{OG} connected between the outputs recreate the differential stage without the disadvantages of the classical design. The current charging the parasitic capacitance at the base of the gain transistor is no longer limited to the fixed current of the current sources and is proportional to the input signal. This improvement results in an approximately 10-times better slew rate.

The amplified current through the gain transistor of one of the buffers is mirrored and becomes the output current. The high-impedance output of the OTA is now buffered by the high current output stage, which is designed to drive long cables or low-impedance loads at full power.

The identical input buffers reduce the input offset to typically less than $\pm 7\mu V$. Closed-loop output offset is typically due to mismatch of the NPN and PNP transistors in the OTA mirror $\pm 100\mu V$ after the output bias current is trimmed.

Figure 5 illustrates the circuit configuration of the voltage-feedback op amp in a complementary circuit design. The feedback buffer and the OTA input buffer form the differential input. Inserting the feedback buffer section transforms the current feedback shown in Figure 4 into the voltage feedback shown in Figure 5.

The resistor R_{OG} sets the open-loop gain and corresponds to the emitter degeneration resistor in a classical differential stage. Because the R_{OG} resistor can be varied externally, a flat frequency response can be achieved over a wide range of applications without the need to compensate the amplifier with a capacitor. In contrast to a current-feedback amplifier, it is possible to adjust the closed-loop gain using the feedback resistors and to adjust the open-loop gain independently using R_{OG} to optimize the frequency response.

Unlike "classical" operational amplifier structures, the OPA622 configuration makes it possible to attain a nearly constant bandwidth for varying closed-loop gains, as well as improved frequency response and large-signal behavior. In addition—and also unlike current-feedback op amps—it provides two identical high-impedance inputs, lower input offset values, and improved CMRR.

CURRENT-FEEDBACK AMPLIFIER

Figure 4 shows the current-feedback configuration. The feedback loop is closed from the output to the BUF+ terminal of the OTA section. The shorter feedback loop

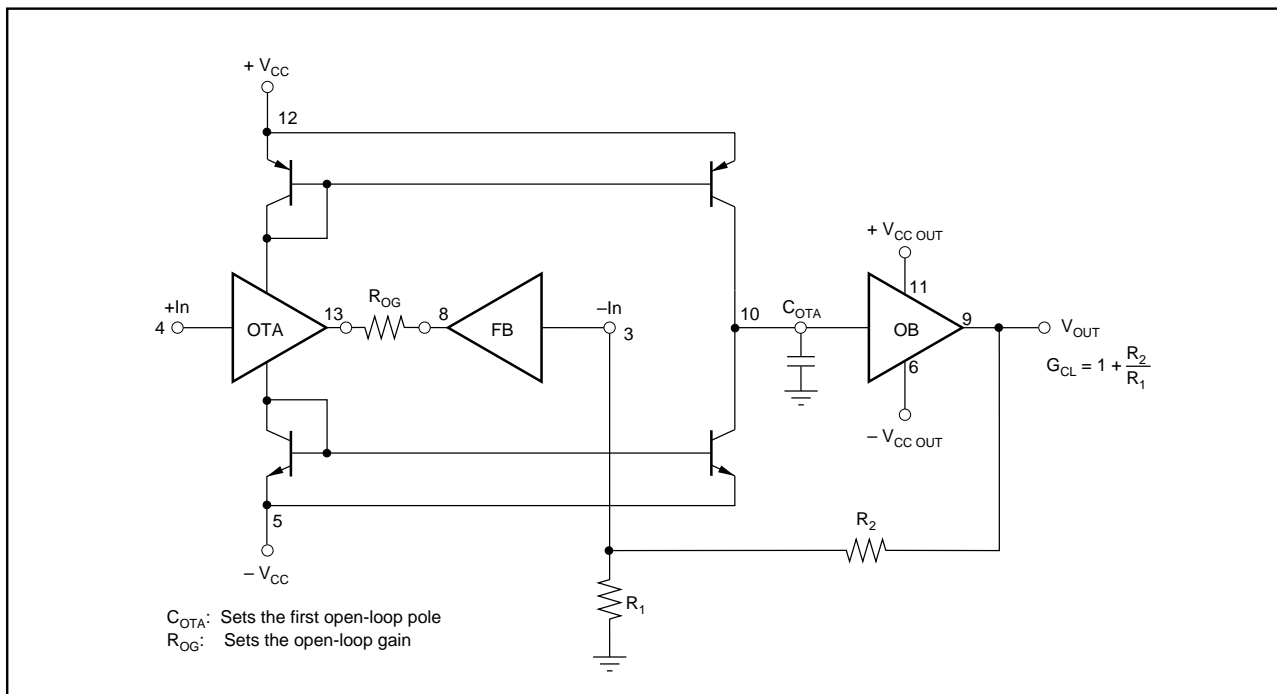


FIGURE 5. Voltage-Feedback Amplifier.

without the feedback buffer produces the wider bandwidth of the current-feedback concept. The additional signal delay time through the feedback buffer determines the difference in AC performance between voltage and current feedback.

The specifications for offset voltage, CMMR, and settling times are the compromise for higher speed.

The open-loop gain for the current-feedback amplifier varies directly with the closed-loop gain and can be adjusted by changing the size of $R_2 \parallel R_1$. For gains of less than 10V/V, the open-loop gain can be adjusted to achieve bandwidth independent of gain, but the effects of this adjustment become limited when second-order effects start to dominate.

Figure 6 gives an overview of the OPA622 inverting and non-inverting amplifier configurations and shows the equations for the closed-loop gains.

OPTIMAL FREQUENCY RESPONSE ADJUSTMENT

Conventional voltage-feedback op amps use a compensation capacitor for stable unity-gain operation. During transitions, the quiescent current charges and discharges this capacitor, and both parameters determine the slew rate according to:

$$SR = \frac{\Delta V_{OUT}}{\Delta t} = \frac{I}{C}$$

This method is not appropriate for wide-band op amps. The slew rate and thus the large-signal behavior are significantly reduced, and the bandwidth decreases with increasing closed-loop gains according to the gain-bandwidth product.

Amplifiers with an external compensation capacitor allow optimal frequency adjustment versus closed-loop gain, but nevertheless do not significantly improve large-signal behavior. The most effective solution is to make the open-loop gain (G_{OL}) externally adjustable.

The widely-used current-feedback op amp type designed with real complementary circuit techniques overcomes the internal compensation capacitor and allows the feedback network to set the open-loop gain. The ratio of the feedback resistors determines the low-frequency closed-loop gain, and the parallel impedance defines the amplifier's open-loop gain for stable operation and flat frequency response. A nearly constant bandwidth can be achieved over a wide range of closed-loop gains. However, current-feedback op amps suffer from nonidentical inputs and poor input offset and CMRR. The voltage-feedback op amp OPA622 with its complementary topology features two identical high-impedance inputs, lower input offset values, and improved CMRR. The ratio of the feedback resistors determines the low-frequency closed-loop gain, and the external resistor R_{OG} sets the open-loop gain to achieve a flat frequency response over a wide range of closed-loop gains. Since R_{OG} can be selected, optimized pulse responses are possible even with larger load capacitances. The OPA622 combines the slew rate enhancements of a complementary amplifier design with the precision of a voltage-feedback system.

The hybrid model shown in Figure 9 describes the AC behavior of a noncompensated wide-band differential op amp. The open-loop frequency response, which is illustrated in Figure 10 for various R_{OG} values, is determined by two

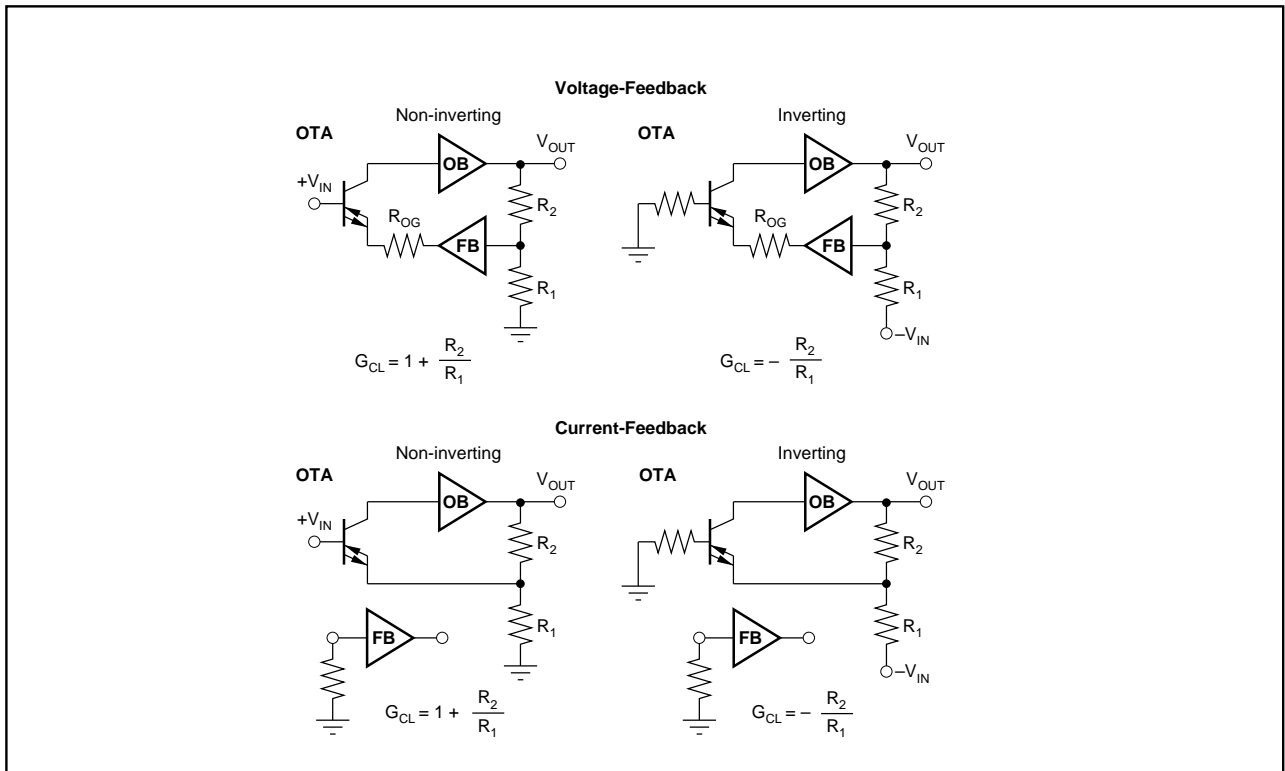


FIGURE 6. Op Amp Configurations for OPA622.

time constants. The elements R and C_{OTA} between the current source output and the output buffer form the first open-loop pole T_C . The signal delay time, T_D , modelled in the output buffer, combines several small phase-shifting time constants and delay times. They are distributed throughout the amplifier and are also present in the feedback loop. As shown in Figure 10, an increasing R_{OG} leads to a decreasing open-loop gain. The ratio of the two time constants, T_C and T_D , of the open-loop frequency response also determines the product $G_{OL} \cdot G_{CL}$ for optimal closed-loop frequency response.

$$G_{OL} = G_{CL}^+ \cdot \frac{T_C}{2T_D}$$

T_C and T_D are fixed by the op amp design. The purpose of R_{OG} now is to vary G_{OL} versus G_{CL} to keep the product $G_{OL} \cdot G_{CL}$ constant, which is the theoretical condition for optimal and gain-independent frequency response. Figure 11 summarizes some optimal flat closed-loop responses and indicates the R_{OG} values. It should be noted that the bandwidth remains relatively constant and R_{OG} has its highest value (low open-loop

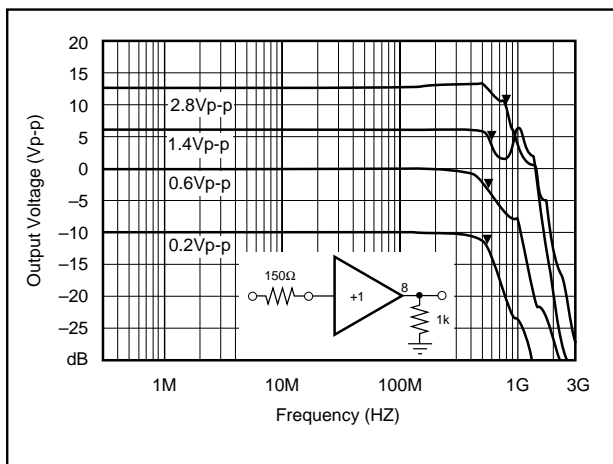


FIGURE 7. Bandwidth vs Output Voltage (Feedback Buffer).

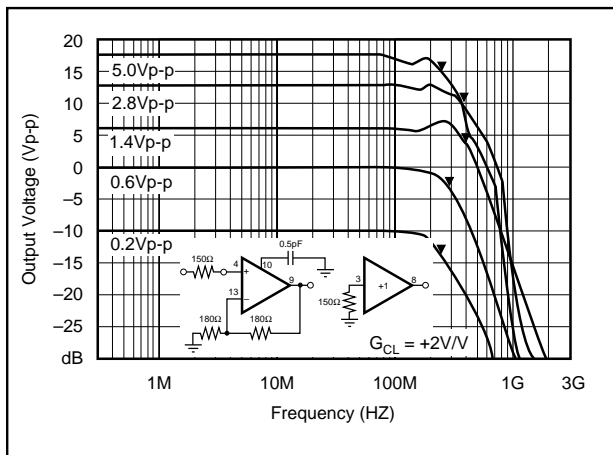


FIGURE 8. Bandwidth vs Output Voltage (Current-Feedback Amplifier).

gain) at low closed-loop gains. Harmonic distortion is also improved with increased open-loop gain. Figure 12 shows the OPA622 frequency response at $G_{CL} = +2V/V$ and variable R_{OG} to demonstrate its influence on a flat frequency response. Slight variation of R_{OG} might be necessary to compensate for load capacitance. It is possible to achieve optimal pulse response over a wide range of load capacitances without overshooting and ringing. As an example, Figure 13 shows a selection curve for the optimal R_{OG} value versus the load capacitance at a gain (G_{CL0}) of $+2V/V$.

THERMAL CONSIDERATIONS

The OPA622 does not require a heat sink for operation in most environments. A heat sink will, however, reduce the internal thermal rise, resulting in cooler, more reliable operation. At extreme temperatures and under full load conditions, a heat sink is necessary. The internal power dissipation is given by the equation $P_D = P_{DQ} + P_{DL}$, (P_{DQ} is the quiescent power dissipation and P_{DL} is the power dissipation in the output stage due to the load). Although the P_{DQ} is very low (50mW at $V_{CC} = \pm 5V$), care should be taken

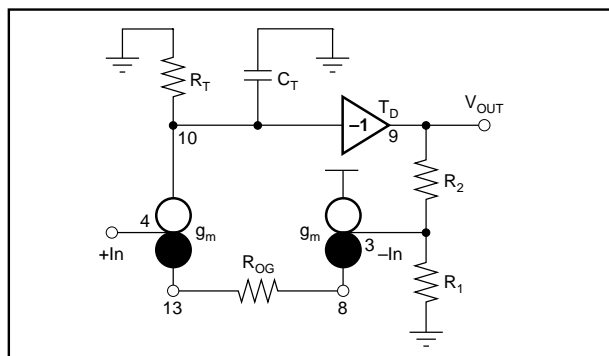


FIGURE 9. Hybrid Model of a Wideband Op Amp.

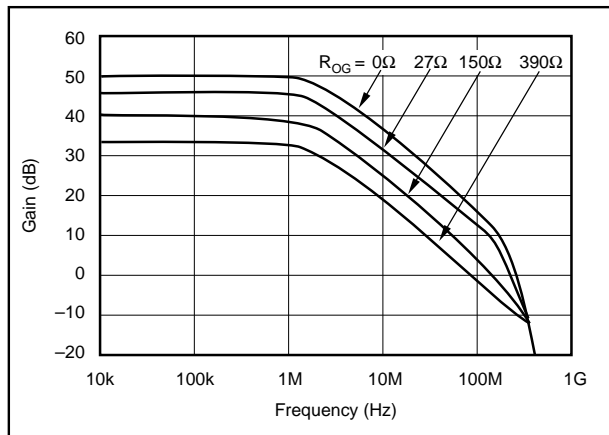


FIGURE 10. Open-Loop Gain vs R_{OG} .

when a signal is applied. For high-speed op amps, a more precise approach to determine power consumption is to measure the average total quiescent current for several typical load conditions. The power consumption of the OPA622 is influenced by the signal type and frequency, the output voltage and load resistor, and the repetition rate of the signal transitions. Figure 14 shows the total average supply current versus the frequency of an applied sine wave for various output voltages. Figure 15 illustrates the total quiescent current versus the repetition frequency of an applied square wave signal.

CIRCUIT LAYOUT

The high-frequency performance of the OPA622 can be greatly affected by the physical layout of the printed circuit board. The following tips are offered as suggestions, not as absolute musts. Oscillations, ringing, poor bandwidth and settling, and peaking are all typical problems that plague high-speed components when they are used incorrectly.

- Bypass power supplies very close to the device pins. Use tantalum chip capacitors (approximately 2.2 μ F) and a parallel 470pF ceramic chip capacitor. Surface-mount types are recommended because of their low lead inductance.
- PC board traces for power lines should be wide to reduce impedance.

- Make short, low-inductance traces. The entire physical circuit should be as small as possible.
- Use a low-impedance ground plane on the component side to ensure that low-impedance ground is available throughout the layout.
- Place the R_{OG} resistor as close as possible to the package and use the shortest possible trace length.
- Do not extend the ground plane over high-impedance nodes sensitive to stray capacitances such as the amplifier's input and R_{OG} terminals.
- Sockets are not recommended, because they add significant inductance and parasitic capacitance. If sockets are required, use zero-profile solderless sockets.
- Use low-inductance, surface-mount components for best AC performance.
- A resistor (50 Ω to 330 Ω) in series with the high-impedance inputs is strictly recommended for stable operation.
- Plug-in prototype boards and wire-wrap boards will not function well. A clean layout using RF techniques is essential.

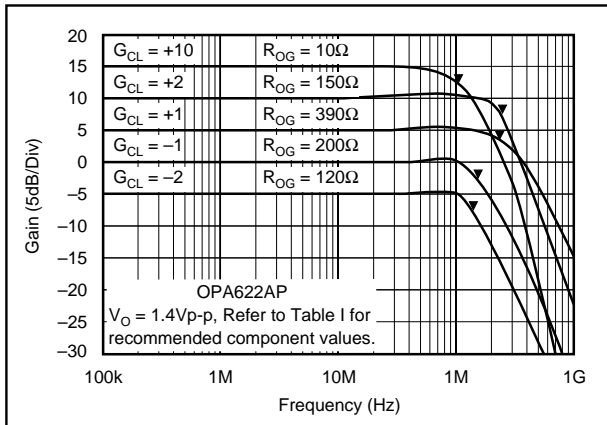


FIGURE 11. Optimum Response vs Closed-Loop Gains.

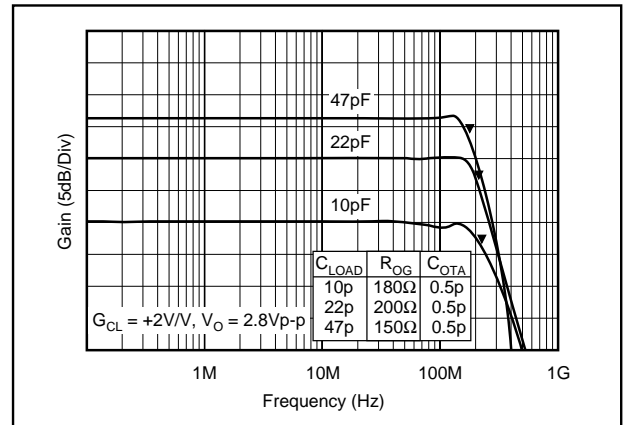


FIGURE 13. Bandwidth vs C_{LOAD} .

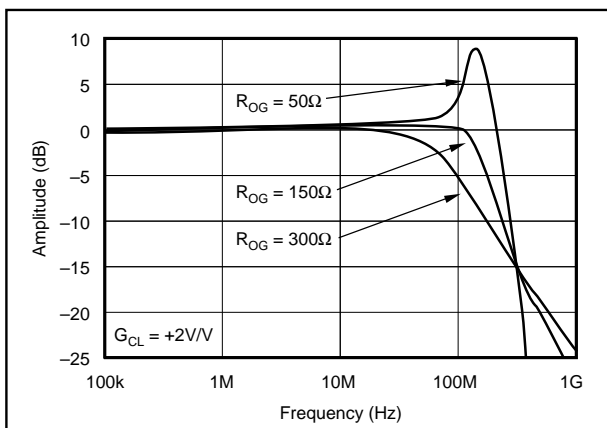


FIGURE 12. Closed-Loop Gain vs R_{OG} .

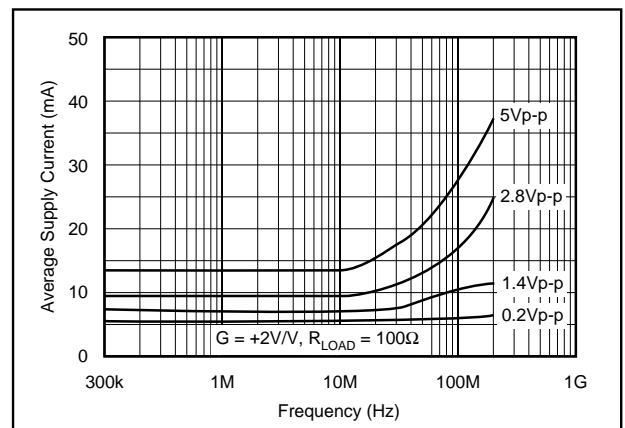


FIGURE 14. Average Supply Current vs Frequency (Sine Wave).

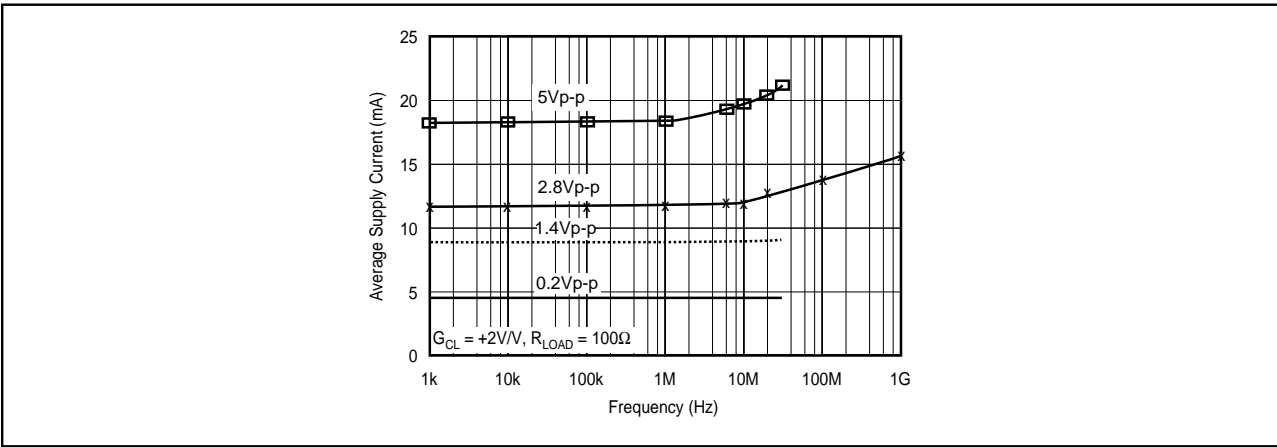


FIGURE 15. Average Supply Current vs Frequency (Square Wave).

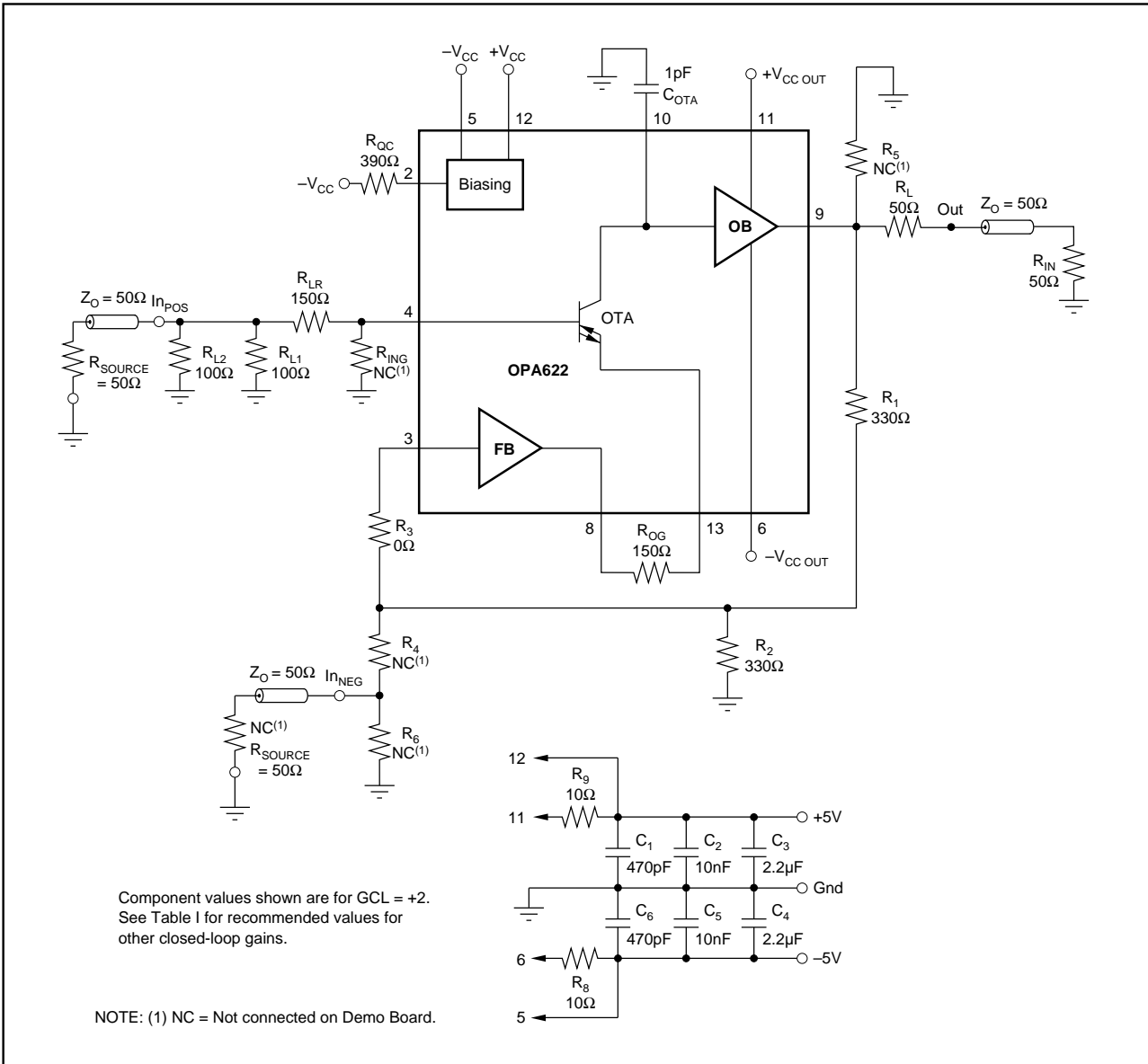


FIGURE 16. Test Circuit Schematic.

RECOMMENDED COMPONENTS VALUES

Table I summarizes recommended component values for optimum flat frequency response. The recommended values were determined with a 100Ω load resistance and a 2pF load capacitance. Some adjustment of circuit values may be required, especially with higher load capacitance. According to the behavior shown in Figure 12, the frequency response will show a peaking when the R_{OG} is decreased and will roll off more gradually when R_{OG} is increased. The C_{OTA} capacitor is responsible for the first open-loop pole and a small external capacitor for the gains +1V/V and +2V/V is

required for stable operation. The package pins, the internal lead frame, and bond wires form a resonant circuit. A resistor in the range of 150Ω to 390Ω in series with all high impedance inputs will damp the package related resonant circuit. Also, the feedback resistor R_1 is in series with the inverting high impedance inputs. $R_1 \geq 330\Omega$ is recommended for the DIP package and $R_1 \geq 150\Omega$ is recommended for the SO-package.

OPA622AP, $I_Q = 5\text{mA}$, $R_{QC} = 430\Omega$ PLASTIC DIP								OPA622AU, $I_Q = 5\text{mA}$, $R_{QC} = 430\Omega$ SURFACE-MOUNT							
Component	G_{CL}						UNITS	Component	G_{CL}						UNITS
	+1	+2	+5	+10	-1	-2			+1	+2	+5	+10	-1	-2	
R_1	0	330	620	1600	390	470	Ω	R_1	150	240	470	820	240	300	Ω
R_2	—	330	160	180	—	—	Ω	R_2	—	240	120	91	—	—	Ω
R_3	220	0	0	0	0	0	Ω	R_3	0	0	0	0	0	0	Ω
R_{OG}	330	150	56	10	200	150	Ω	R_{OG}	270	150	47	10	160	100	Ω
C_{OTA}	2.2	1	—	—	1	1	pF	C_{OTA}	2.2	1	—	—	1	1	pF
R_{ILR}	150	150	150	150	150	150	Ω	R_{ILR}	200	150	200	200	150	150	Ω
R_4	—	—	—	—	390	240	Ω	R_4	—	—	—	—	240	150	Ω
R_5	—	—	—	—	62	62	Ω	R_5	—	—	—	—	68	68	Ω
Ring	—	—	—	—	150	150	Ω	Ring	—	—	—	—	150	150	Ω
Bandwidth															
$V_{OUT} = 0.2\text{Vp-p}$	170	160	140	110	135	125	MHz	$V_{OUT} = 0.2\text{Vp-p}$	200	170	160	100	180	175	MHz
$V_{OUT} = 2.8\text{Vp-p}$	220	200	170	110	150	150	MHz	$V_{OUT} = 2.3\text{Vp-p}$	250	240	230	100	250	240	MHz

TABLE I. Recommended Components Values for Optimum Frequency Performance.

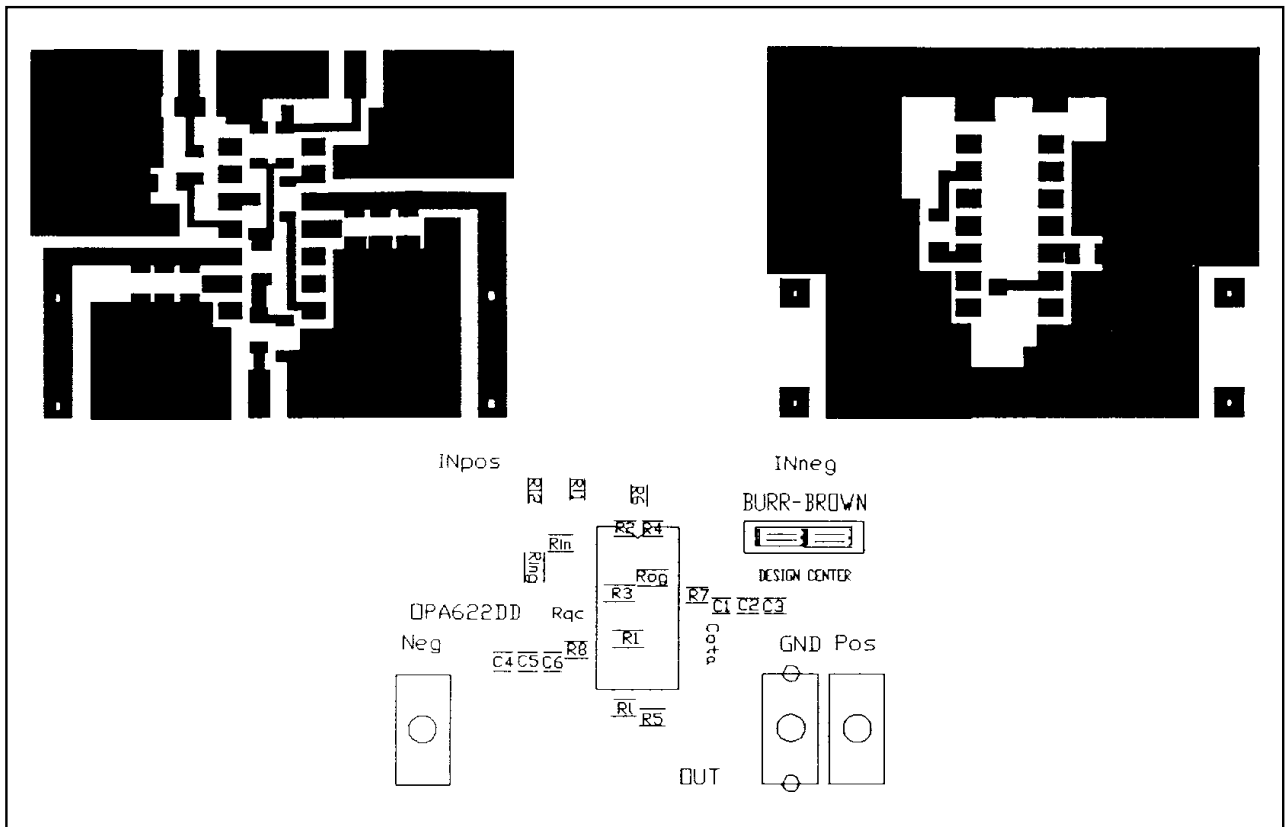


FIGURE 17. Silkscreen and Test Circuit Board Layouts.

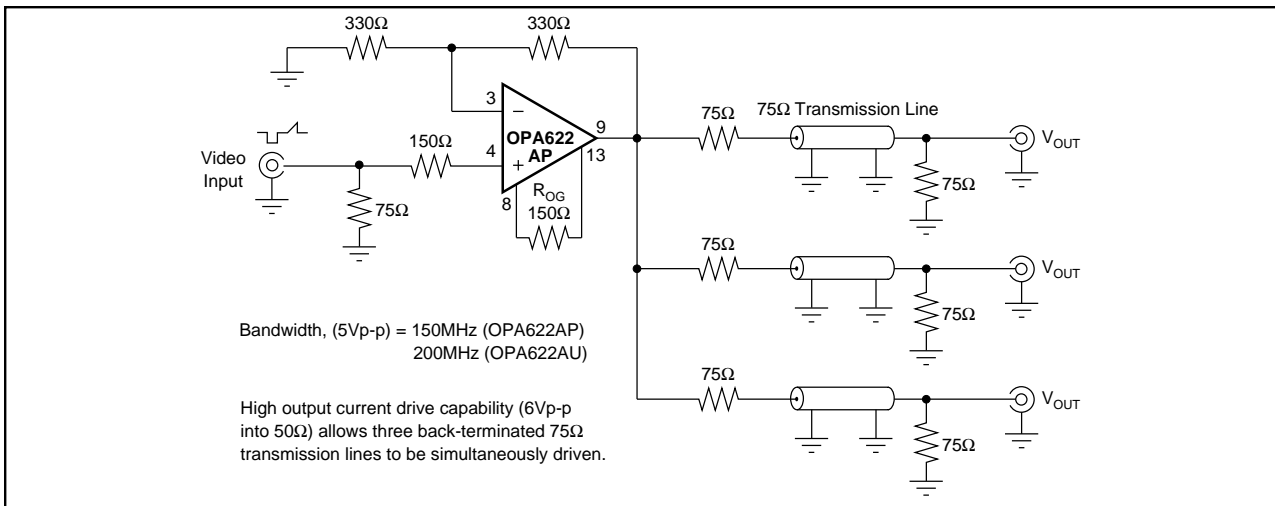


FIGURE 18. Video Distribution Amplifier.

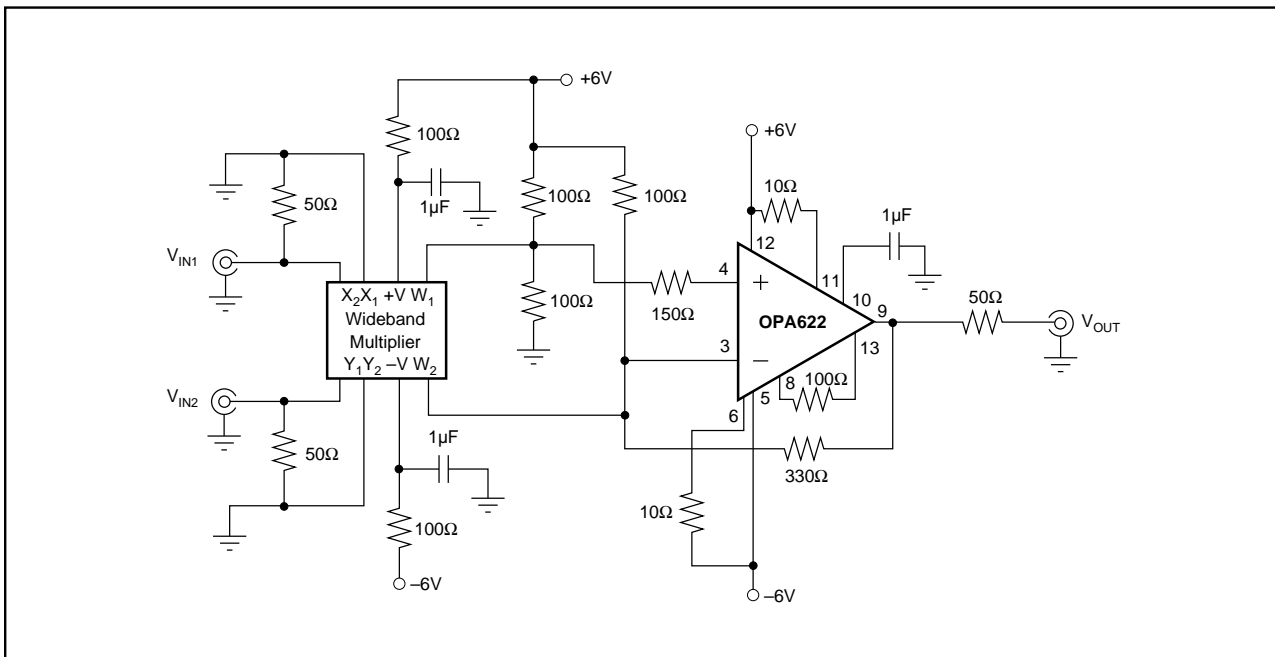


FIGURE 19. Wideband Multiplier Output Amplifier.

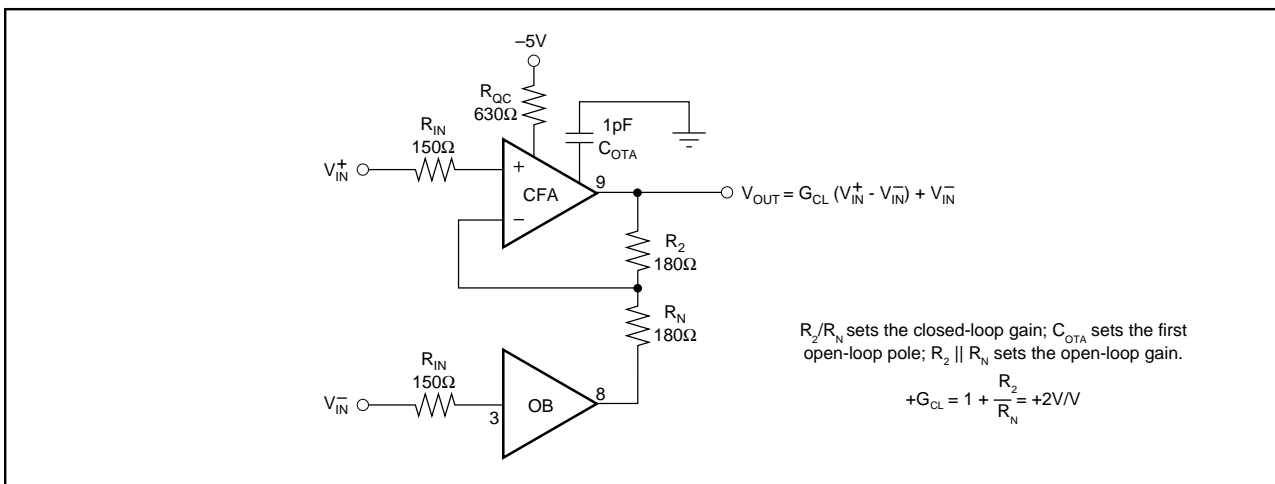


FIGURE 20. Current-Feedback Amplifier with Two Equal and High Impedance Inputs.

IMPORTANT NOTICE

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

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

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

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

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

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

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

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

Products

Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
RF/IF and ZigBee® Solutions	www.ti.com/lprf

Applications

Audio	www.ti.com/audio
Automotive	www.ti.com/automotive
Broadband	www.ti.com/broadband
Digital Control	www.ti.com/digitalcontrol
Medical	www.ti.com/medical
Military	www.ti.com/military
Optical Networking	www.ti.com/opticalnetwork
Security	www.ti.com/security
Telephony	www.ti.com/telephony
Video & Imaging	www.ti.com/video
Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2008, Texas Instruments Incorporated