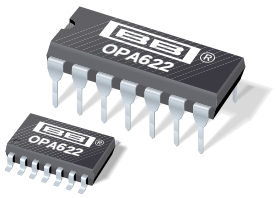
BURR - BROWN®



OPA622

Wide-Bandwidth OPERATIONAL AMPLIFIER

FEATURES

- LARGE SIGNAL BANDWIDTH: 150MHz (AP), 200MHz (AU) (Voltage-Feedback)
- HIGH OUTPUT CURRENT: ±70mA
- 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: –1.2µA

APPLICATIONS

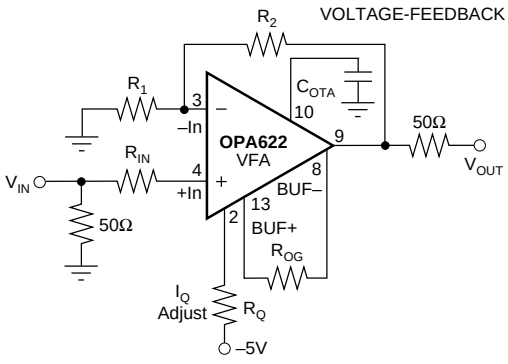
- BROADCAST/HDTV EQUIPMENT
- COMMUNICATIONS
- PULSE/RF AMPLIFIERS
- ACTIVE FILTER
- HIGH SPEED ANALOG SIGNAL PROCESSING
- MULTIPLIER OUTPUT AMP
- DIFFERENTIATOR FOR DIGITIZED VIDEO SIGNALS

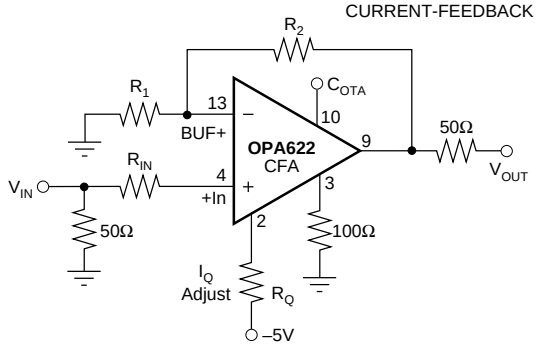
DESCRIPTION

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 ±2.5V output level and a 1700V/µs slew rate. The output buffer stage can deliver ±70mA output current. The high output current capability allows the OPA622 to drive two 50Ω or 75Ω lines with ±3V 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

PDS-1131E
Printed in U.S.A. March, 1995

SPECIFICATIONS

DC-SPECIFICATION
VOLTAGE-FEEDBACK AMPLIFIER (Figure 5)

At V_{CC} = ±5V, I_Q = ±5mA, G_{CL} = +2V/V, R_{LOAD} = 100Ω, R_{SOURCE} = 50Ω, R_Q = 430Ω, R_{OG} = 150Ω and T_A = +25°C, unless otherwise specified.

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

ABSOLUTE MAXIMUM RATINGS

Power Supply Voltage	±6V
Input Voltage[1]	±V_{CC} to ±0.7V
Operating Temperature	–40°C to +85°C
Storage Temperature	–40°C to +125°C
Junction Temperature	+150°C
Lead Temperature (soldering, 10s)	+300°C

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

ORDERING INFORMATION

MODEL	DESCRIPTION	TEMPERATURE RANGE
OPA622AP	14-Pin Plastic DIP	–40°C to +85°C
OPA622AU	SO-14 Surface-Mount	–40°C to +85°C

PACKAGE INFORMATION

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

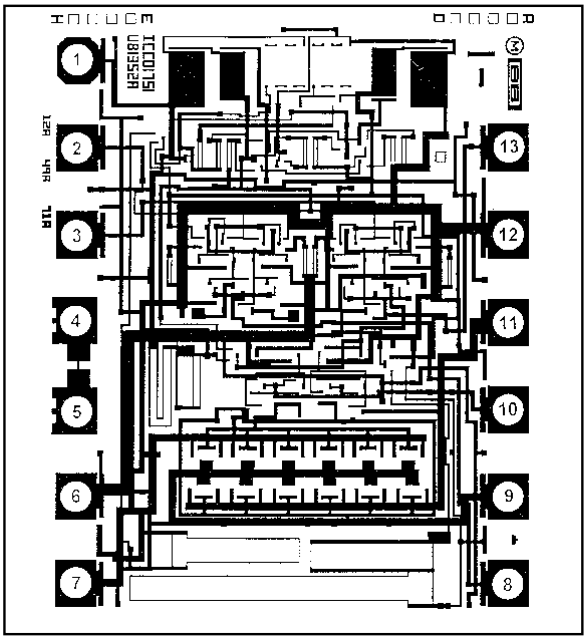
NOTE:(1) For detailed drawing and dimension table, please see end of data sheet, or Appendix D of Burr-Brown IC Data Book.

AC-SPECIFICATION
VOLTAGE-FEEDBACK AMPLIFIER (Figure 5)

At V_{CC} = ±5V, I_Q = ±5mA, G_{CL} = +2V/V, R_{LOAD} = 100Ω, R_{SOURCE} = 50Ω, R_Q = 430Ω, R_{OG} = 150Ω and T_A = +25°C, unless otherwise specified.

PARAMETER	CONDITIONS	OPA622AP TYP	OPA622AU TYP	UNITS
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} = 150Ω			
	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} = 150Ω			
	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	ns
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	Vµs
SETTLING TIME	Gain = +2V/V, Rise Time = 2ns V_O = 2Vp-p, 0.1%	17	17	ns

DICE INFORMATION



OPA622AD DIE TOPOGRAPHY

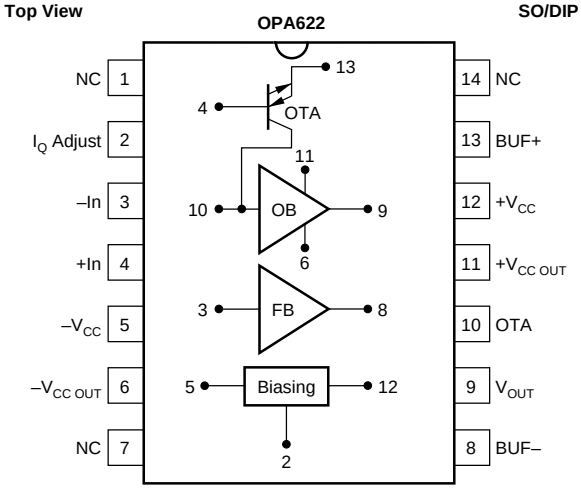
PAD	FUNCTION
1	Quiescent Current Adjustment
2	Inverting Analog Input
3	Non-Inverting Analog Input
4	NC
5	NC
6	–5V Supply
7	–5V Supply, Output
8	Inverting Buffer Output
9	Analog Output
10	Analog OTA Output
11	+5V Supply, Output
12	+5V Supply
13	Non-Inverting Buffer Output

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.

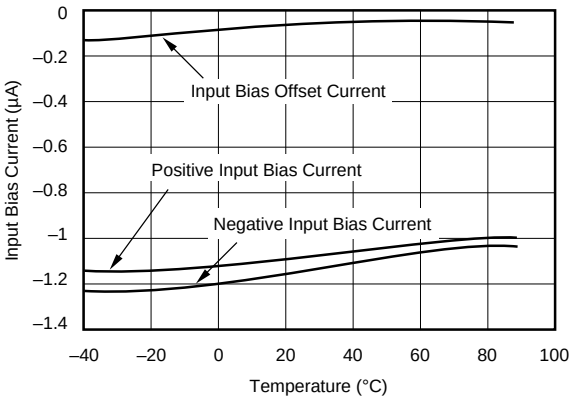
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet published specifications.

TYPICAL PERFORMANCE CURVES

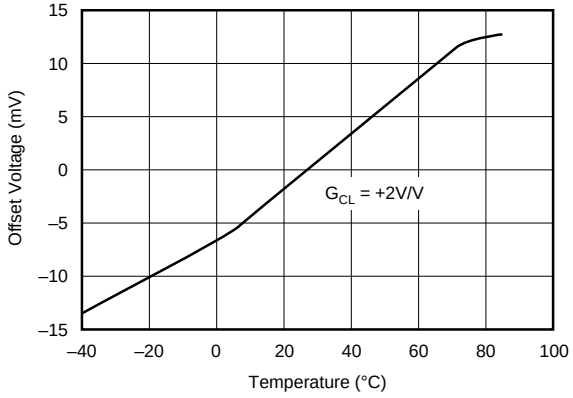
VOLTAGE-FEEDBACK AMPLIFIER (Figure 5)

At V_{CC} = ±5V, I_Q = ±5mA, G_{CL} = +2V/V, R_{LOAD} = 100Ω, R_{SOURCE} = 50Ω, R_Q = 430Ω, R_{OG} = 150Ω and T_A = +25°C, unless otherwise specified.

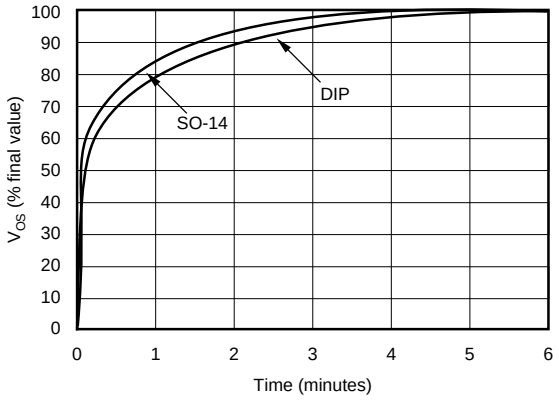
INPUT BIAS CURRENT vs TEMPERATURE



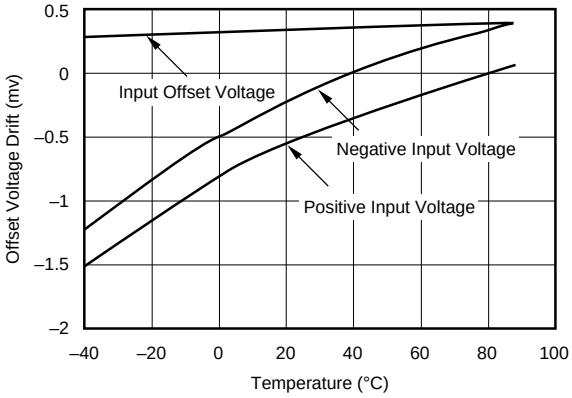
CLOSED-LOOP OUTPUT OFFSET VOLTAGE vs TEMPERATURE



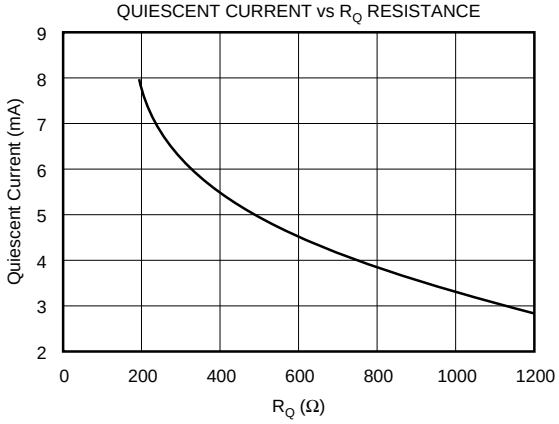
INPUT OFFSET VOLTAGE vs TIME



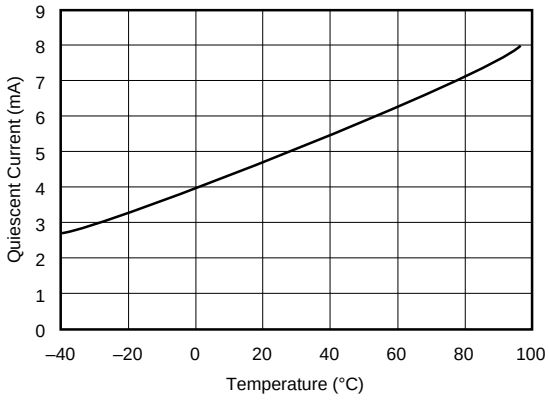
INPUT STAGE OFFSET VOLTAGE vs TEMPERATURE



QUIESCENT CURRENT vs R_Q RESISTANCE



QUIESCENT CURRENT vs TEMPERATURE

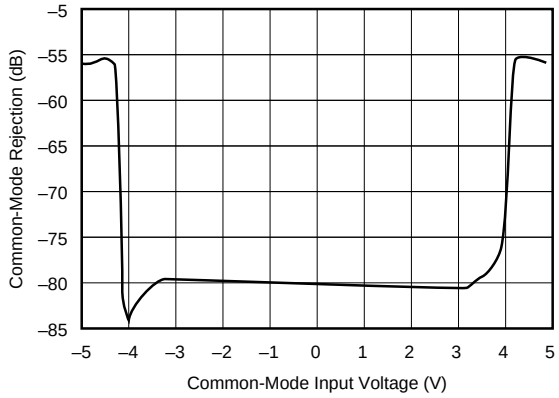


TYPICAL PERFORMANCE CURVES (CONT)

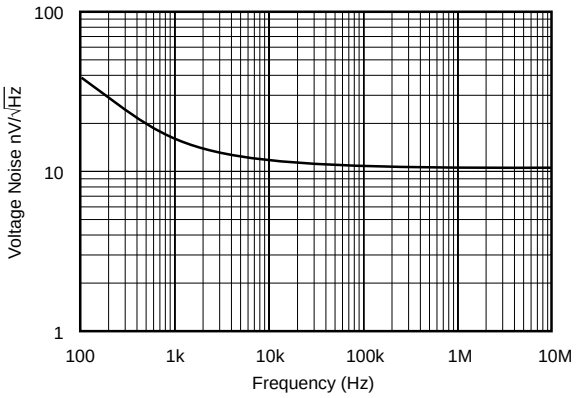
VOLTAGE-FEEDBACK AMPLIFIER (Figure 5)

At V_{CC} = ±5V, I_Q = ±5mA, G_{CL} = +2V/V, R_{LOAD} = 100Ω, R_{SOURCE} = 50Ω, R_Q = 430Ω, R_{OG} = 150Ω and T_A = +25°C, unless otherwise specified.

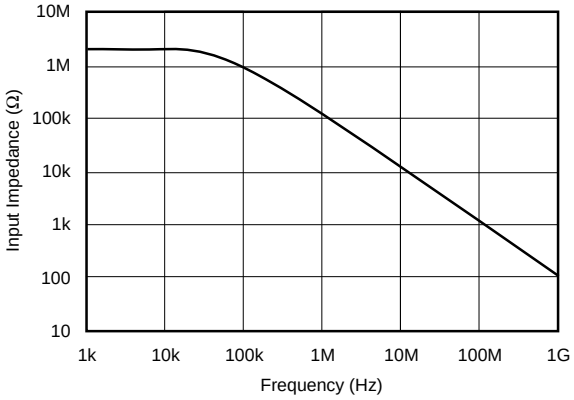
COMMON-MODE REJECTION
vs COMMON-MODE INPUT VOLTAGE



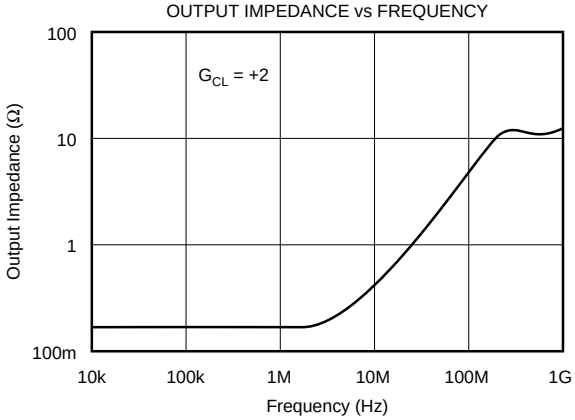
SPECTRAL NOISE VOLTAGE DENSITY



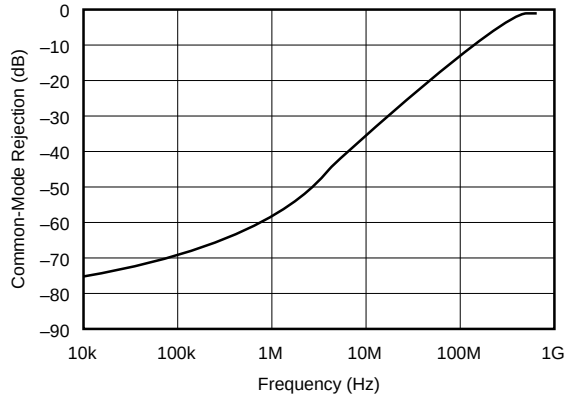
INPUT IMPEDANCE vs FREQUENCY



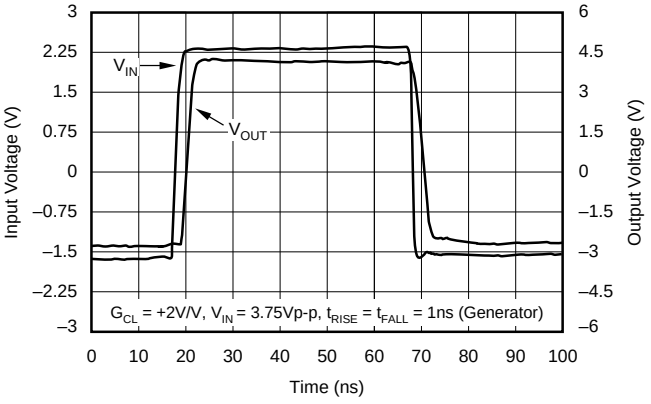
OUTPUT IMPEDANCE vs FREQUENCY



COMMON-MODE REJECTION vs FREQUENCY



OVERLOAD RECOVERY CHARACTERISTICS

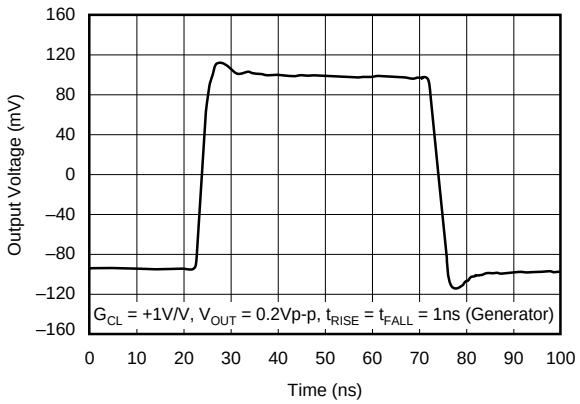


TYPICAL PERFORMANCE CURVES (CONT)

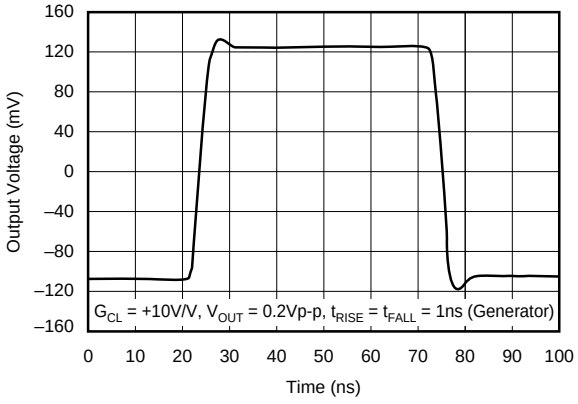
VOLTAGE-FEEDBACK AMPLIFIER (Figure 5)

At V_{CC} = ±5V, I_Q = ±5mA, G_{CL} = +2V/V, R_{LOAD} = 100Ω, R_{SOURCE} = 50Ω, R_Q = 430Ω, R_{OG} = 150Ω and T_A = +25°C, unless otherwise specified.

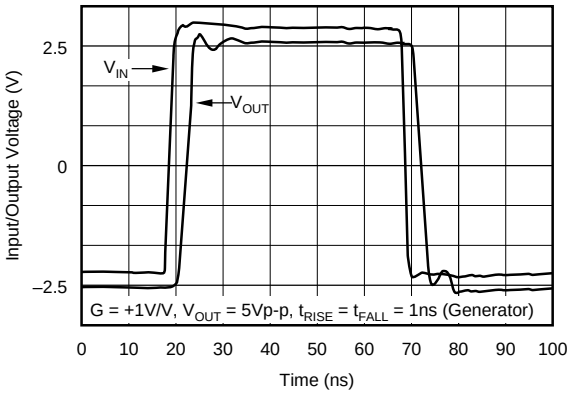
SMALL SIGNAL PULSE RESPONSE



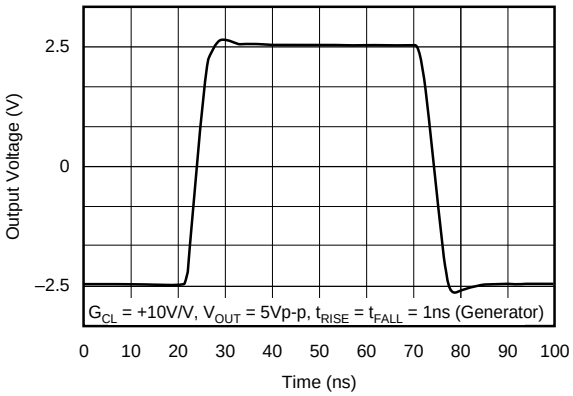
SMALL SIGNAL PULSE RESPONSE



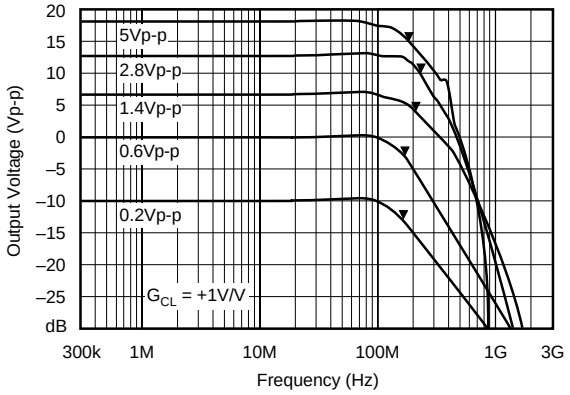
LARGE SIGNAL PULSE RESPONSE



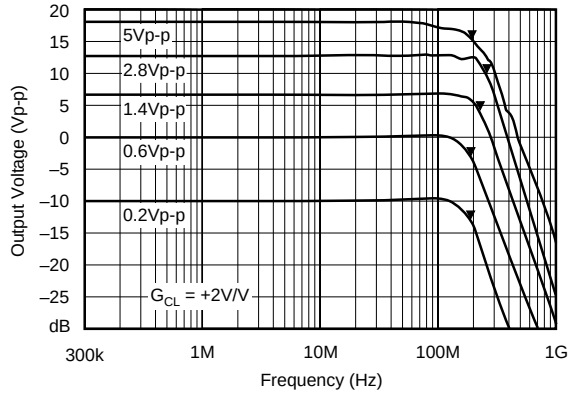
LARGE SIGNAL PULSE RESPONSE



BANDWIDTH vs OUTPUT VOLTAGE



BANDWIDTH vs OUTPUT VOLTAGE

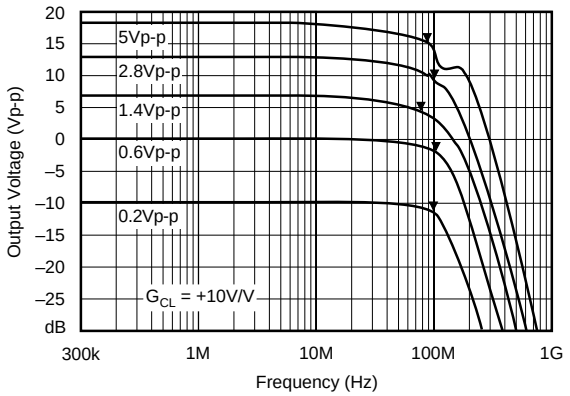


TYPICAL PERFORMANCE CURVES (CONT)

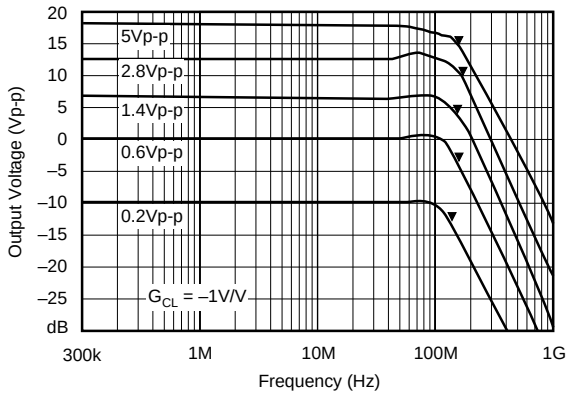
VOLTAGE-FEEDBACK AMPLIFIER (Figure 5)

At V_{CC} = ±5V, I_Q = ±5mA, G_{CL} = +2V/V, R_{LOAD} = 100Ω, R_{SOURCE} = 50Ω, R_Q = 430Ω, R_{OG} = 150Ω and T_A = +25°C, unless otherwise specified.

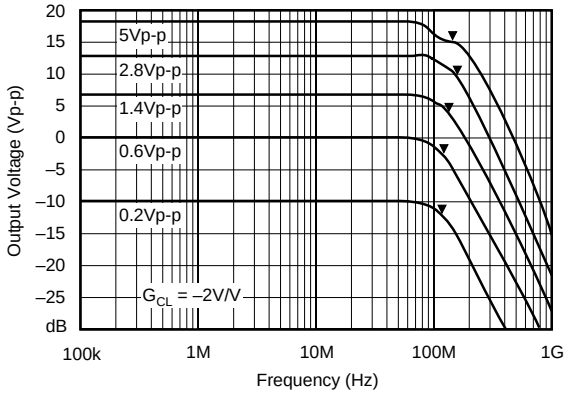
BANDWIDTH vs OUTPUT VOLTAGE



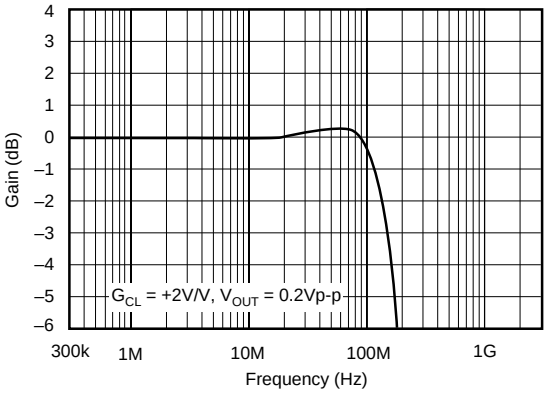
BANDWIDTH vs OUTPUT VOLTAGE



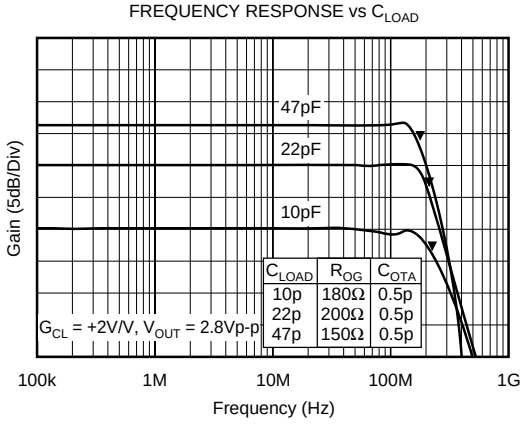
BANDWIDTH vs OUTPUT VOLTAGE



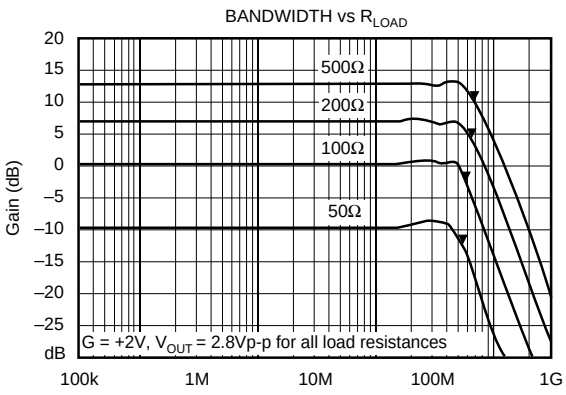
GAIN FLATNESS



FREQUENCY RESPONSE vs C_{LOAD}



BANDWIDTH vs R_{LOAD}

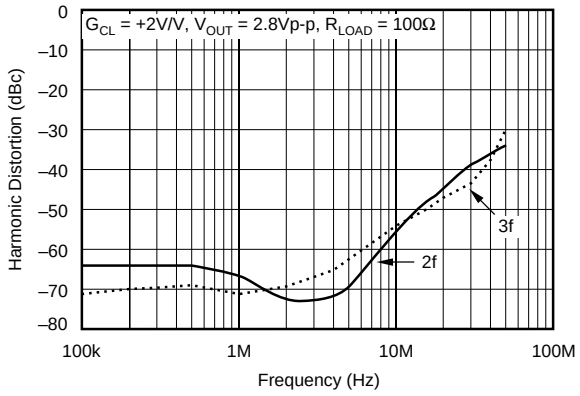


TYPICAL PERFORMANCE CURVES (CONT)

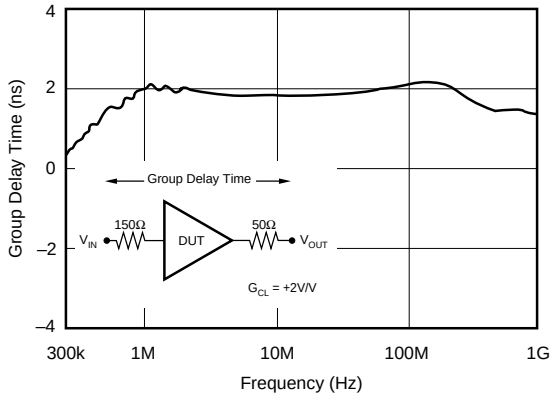
VOLTAGE-FEEDBACK AMPLIFIER (Figure 5)

At V_{CC} = ±5V, I_Q = ±5mA, G_{CL} = +2V/V, R_{LOAD} = 100Ω, R_{SOURCE} = 50Ω, R_Q = 430Ω, R_{OG} = 150Ω and T_A = +25°C, unless otherwise specified.

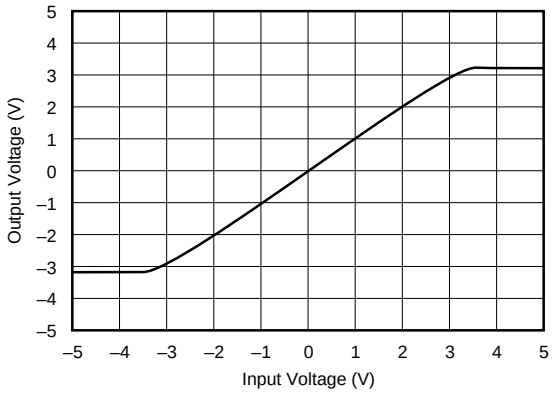
HARMONIC DISTORTION vs FREQUENCY



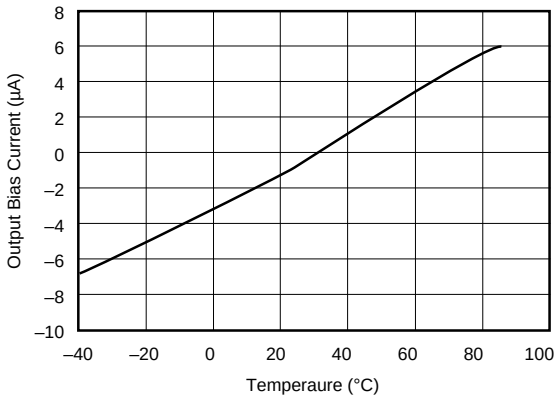
GROUP DELAY TIME vs FREQUENCY



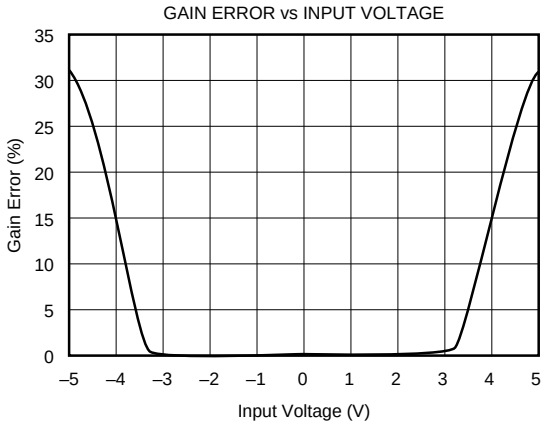
TRANSFER FUNCTION



OUTPUT BIAS CURRENT vs TEMP



GAIN ERROR vs INPUT VOLTAGE



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.

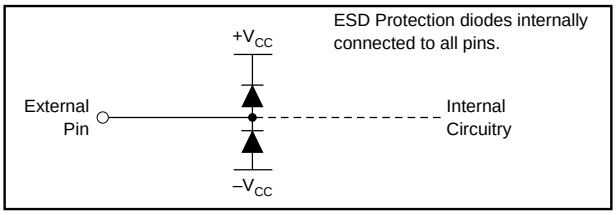


FIGURE 1. Internal ESD Protection.

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 ±5mA with R_Q = 430Ω. The recommended range is ±3mA to ±8mA.

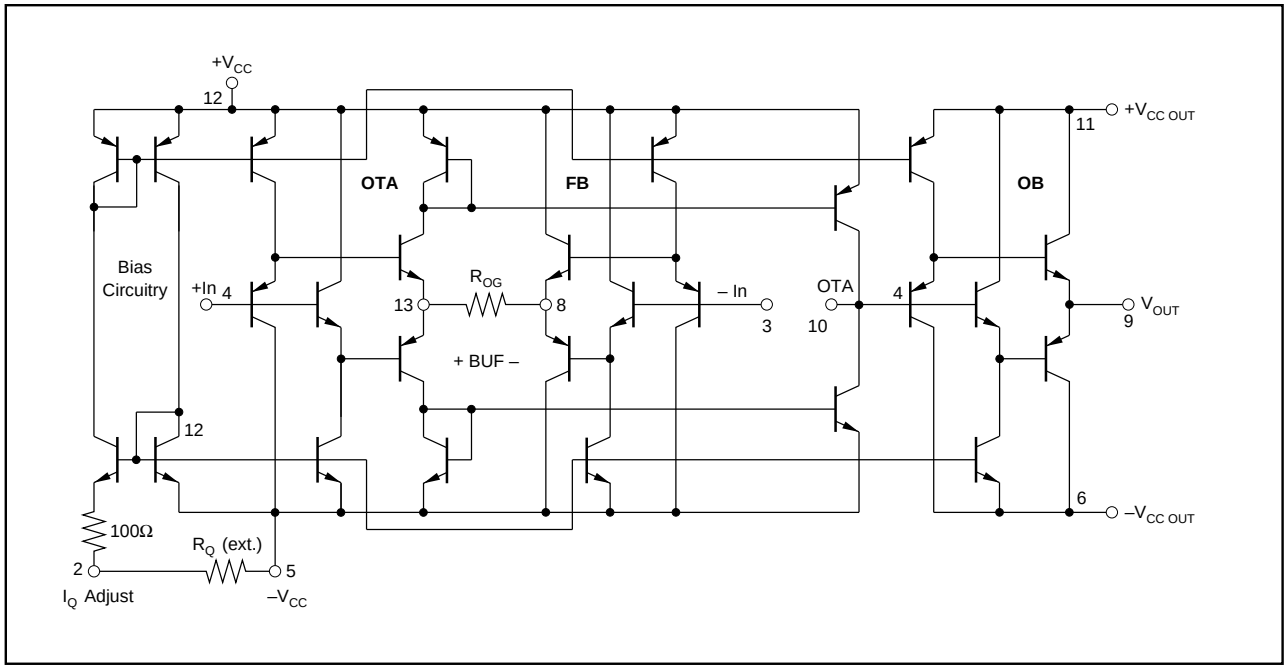


FIGURE 2. Simplified Circuit Diagram.

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.

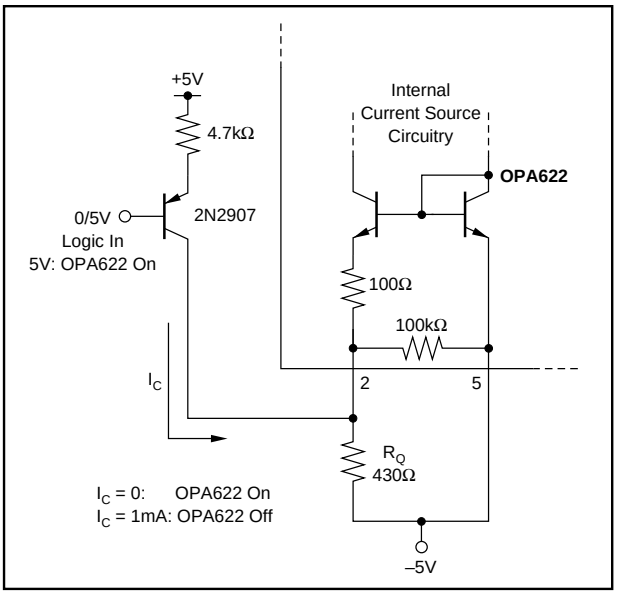


FIGURE 3. Logic-Controlled Disable Circuit.

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.

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.

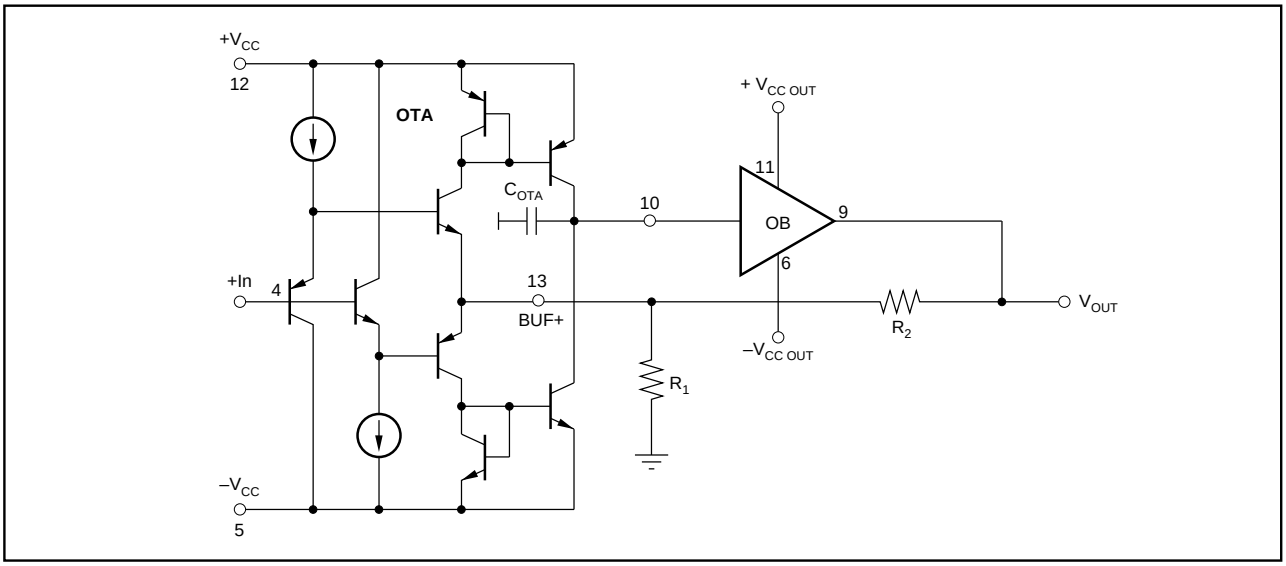


FIGURE 4. Current-Feedback Amplifier.

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 ±7µV. Closed-loop output offset is typically due to mismatch of the NPN and PNP transistors in the OTA mirror ±100µV 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

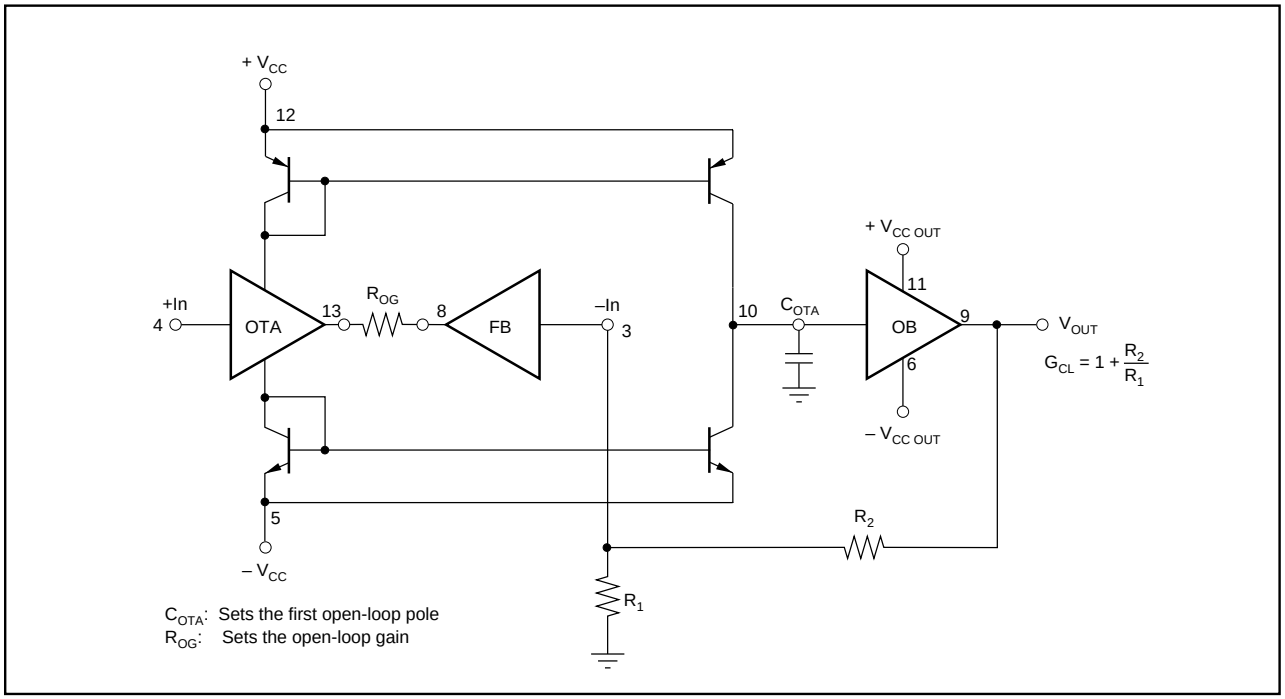


FIGURE 5. Voltage-Feedback Amplifier.

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 $R_2||R_1$. 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

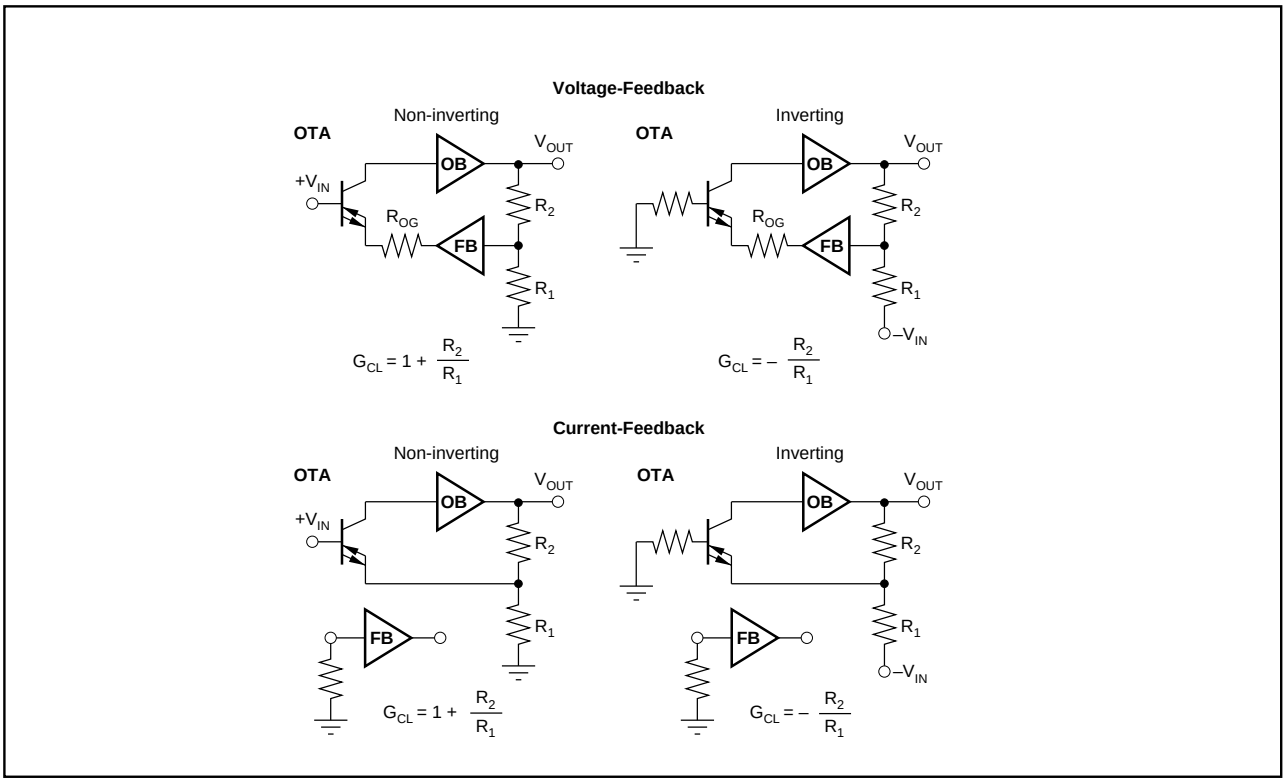


FIGURE 6. Op Amp Configurations for OPA622.

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 $G_{OL} \bullet G_{CL}$ for optimal closed-loop frequency response.

$$G_{OL} = G^{+}_{CL} \bullet \frac{T_C}{2T_D}$$

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 $G_{OL} \bullet G_{CL}$ 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 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_{CLO}) 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} = ±5V), care should be taken

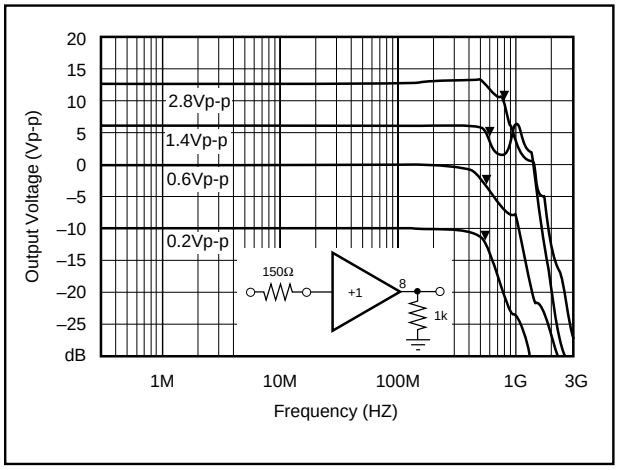


FIGURE 7. Bandwidth vs Output Voltage (Feedback Buffer).

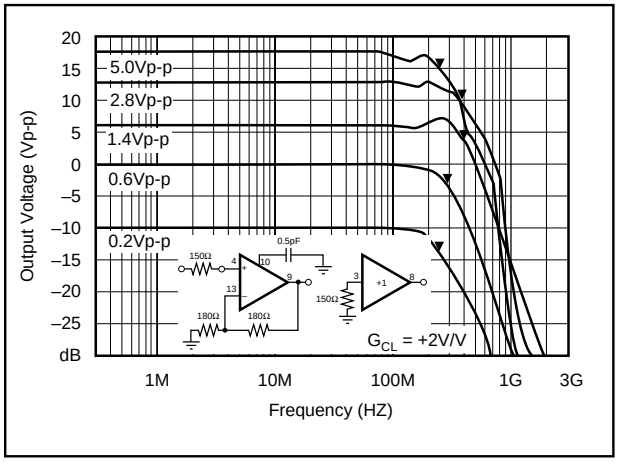


FIGURE 8. Bandwidth vs Output Voltage (Current-Feedback Amplifier).

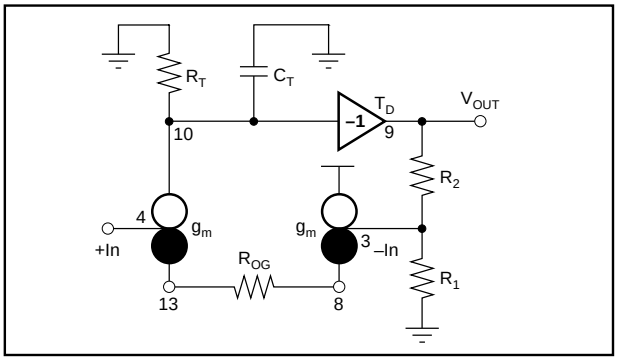


FIGURE 9. Hybrid Model of a Wideband Op Amp.

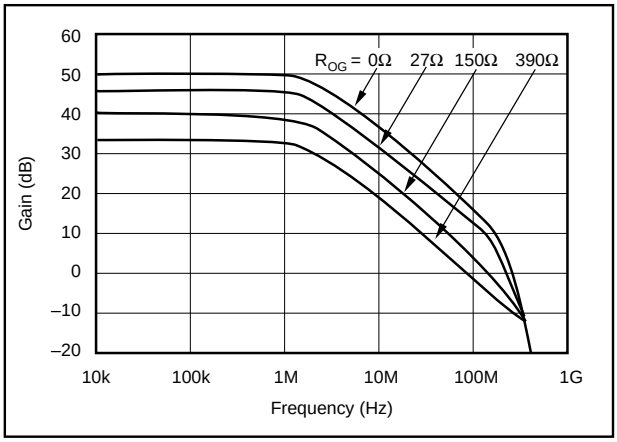


FIGURE 10. Open-Loop Gain vs R_{OG}.

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 2.2µF) 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 (50Ω to 330Ω) 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.

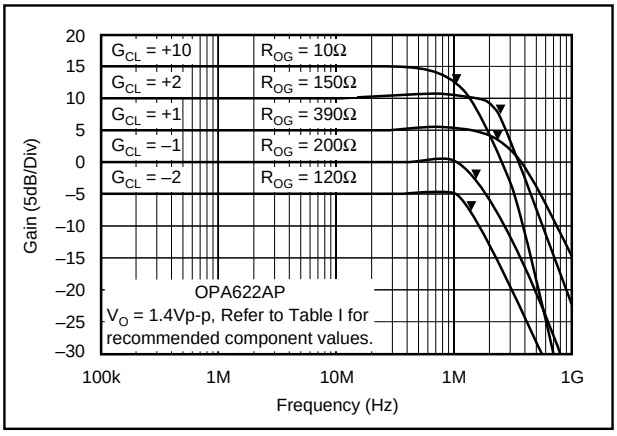


FIGURE 11. Optimum Response vs Closed-Loop Gains.

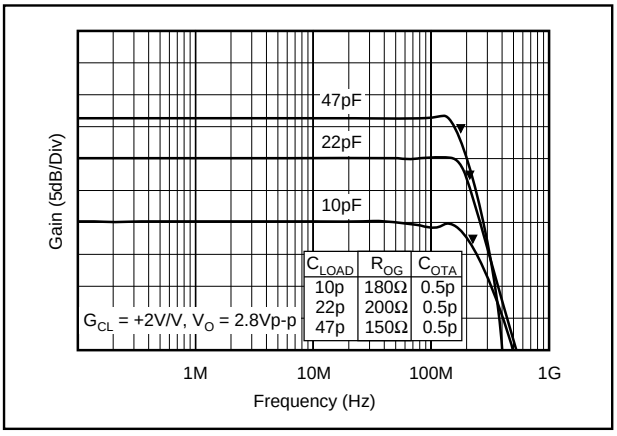


FIGURE 13. Bandwidth vs C_{LOAD}.

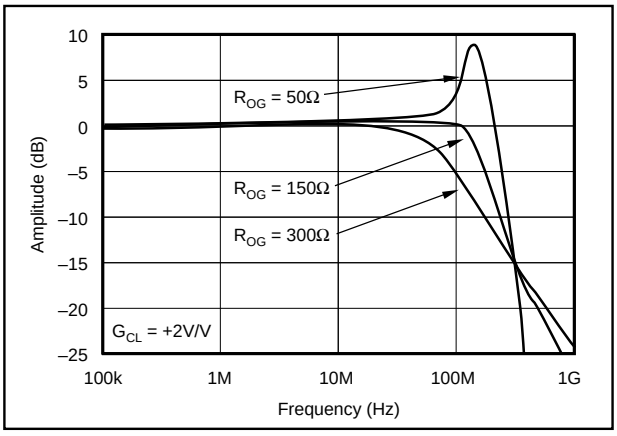


FIGURE 12. Closed-Loop Gain vs R_{OG}.

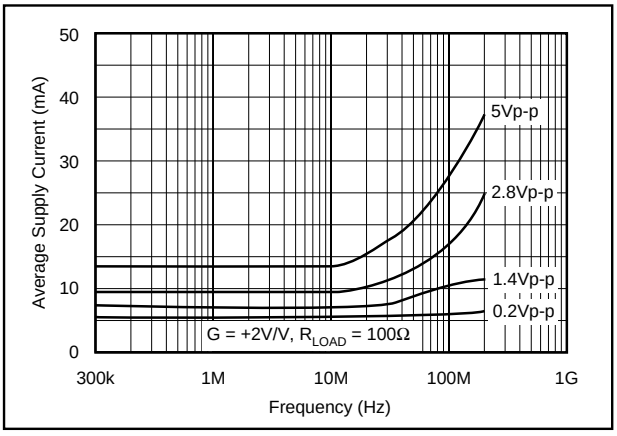


FIGURE 14. Average Supply Current vs Frequency (Sine Wave).

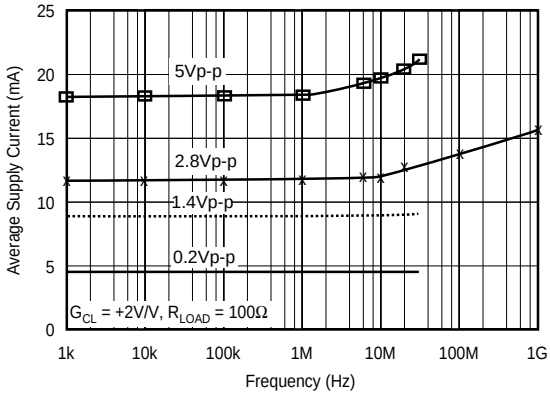


FIGURE 15. Average Supply Current vs Frequency (Square Wave).

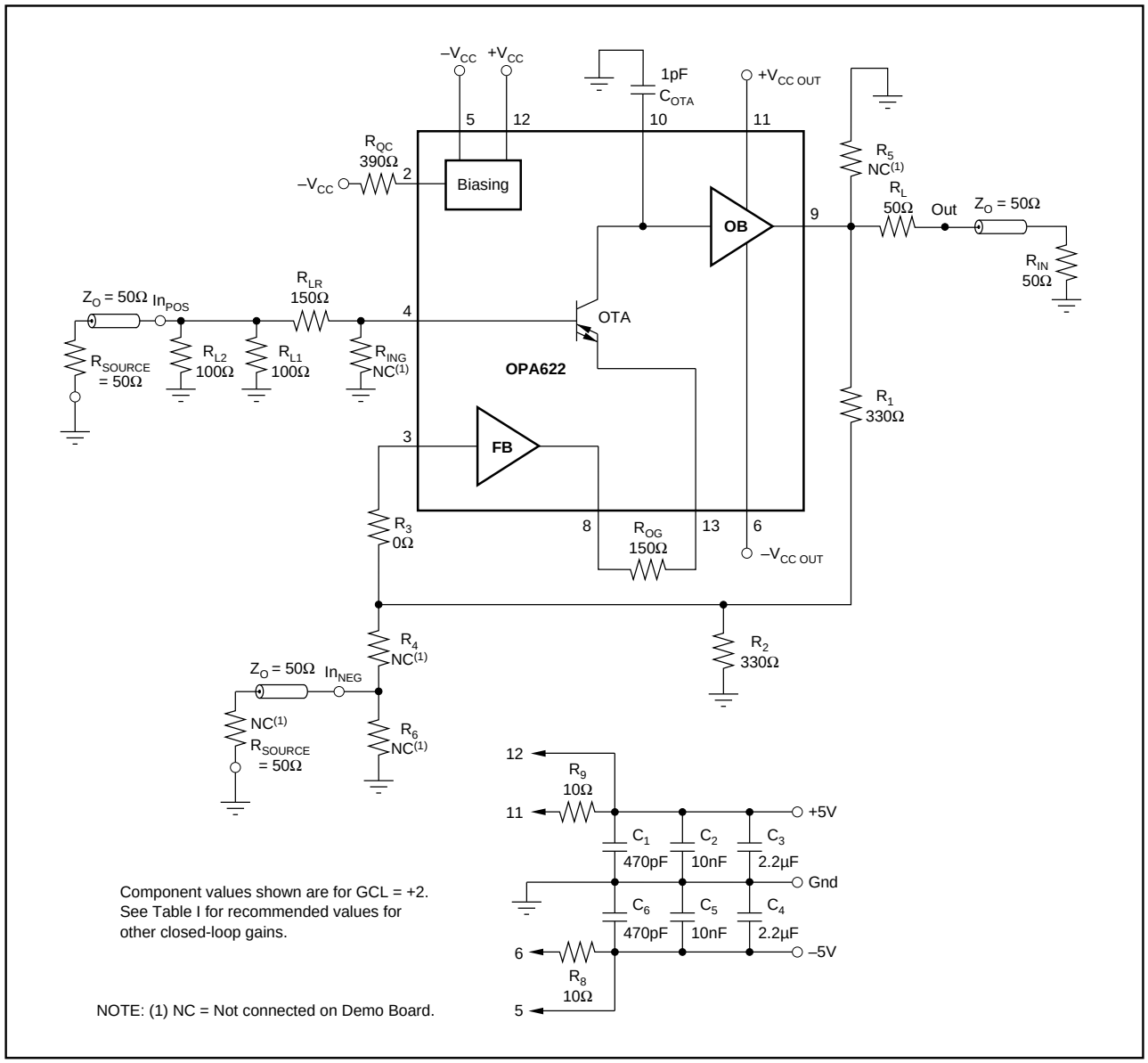


FIGURE 16. Test Circuit Schematic.

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 = 5mA, R_{QC} = 430Ω PLASTIC DIP								OPA622AU, I_Q = 5mA, R_{QC} = 430Ω SURFACE-MOUNT							
	G_{CL}								G_{CL}						
Component	+1	+2	+5	+10	–1	–2	UNITS	Component	+1	+2	+5	+10	–1	–2	UNITS
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_{LR}	200	150	200	200	150	150	Ω
R_4	—	—	—	—	390	240	Ω	R_4	—	—	—	—	240	150	Ω
R_5	—	—	—	—	62	62	Ω	R_6	—	—	—	—	68	68	Ω
Ring	—	—	—	—	150	150	Ω	Ring	—	—	—	—	150	150	Ω
Bandwidth								Bandwidth							
V_{OUT} = 0.2Vp-p	170	160	140	110	135	125	MHz	V_{OUT} = 0.2Vp-p	200	170	160	100	180	175	MHz
V_{OUT} = 2.8Vp-p	220	200	170	110	150	150	MHz	V_{OUT} = 2.3Vp-p	250	240	230	100	250	240	MHz

TABLE I. Recommended Components Values for Optimum Frequency Performance.

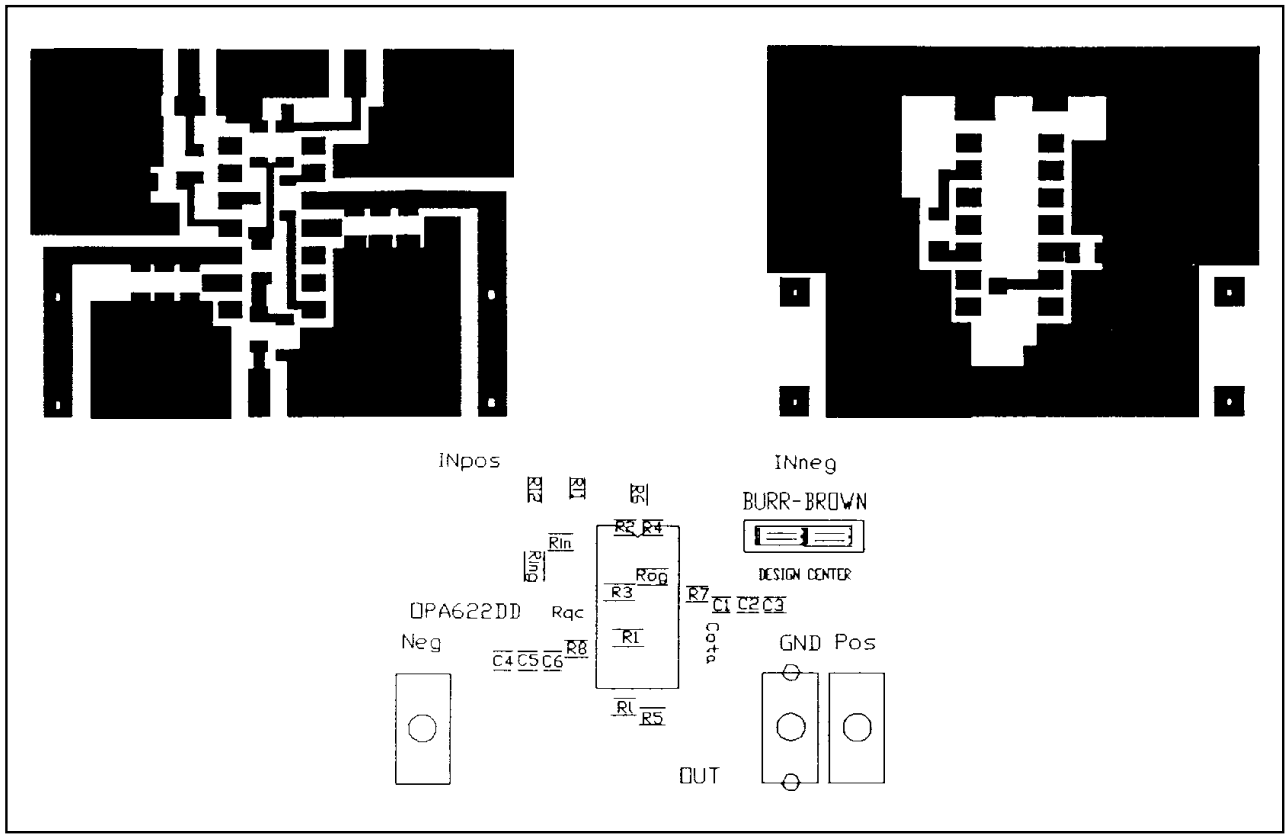


FIGURE 17. Silkscreen and Test Circuit Board Layouts.

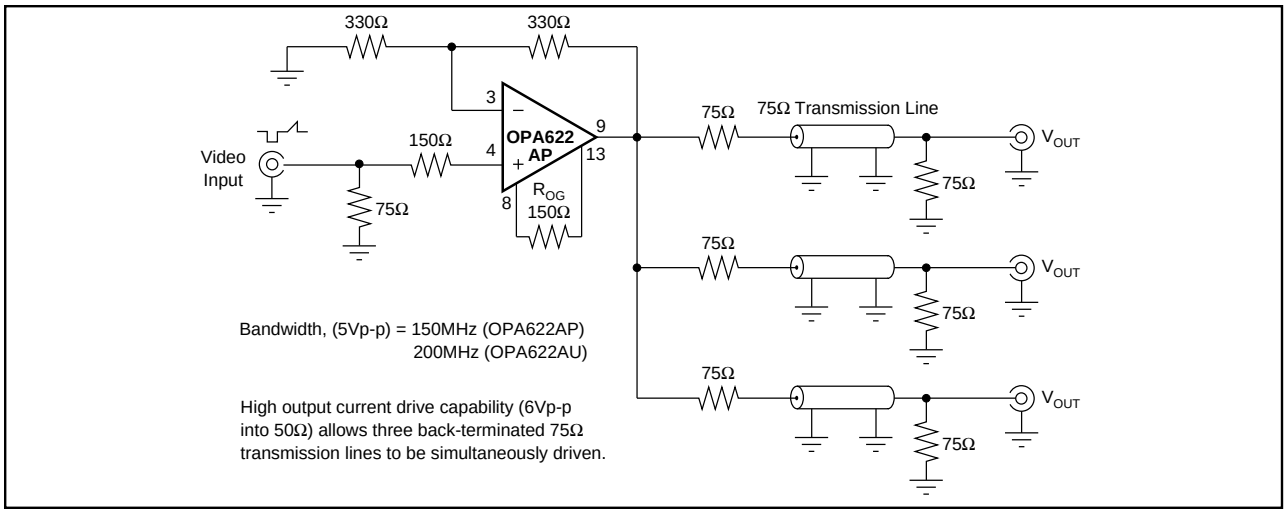


FIGURE 18. Video Distribution Amplifier.

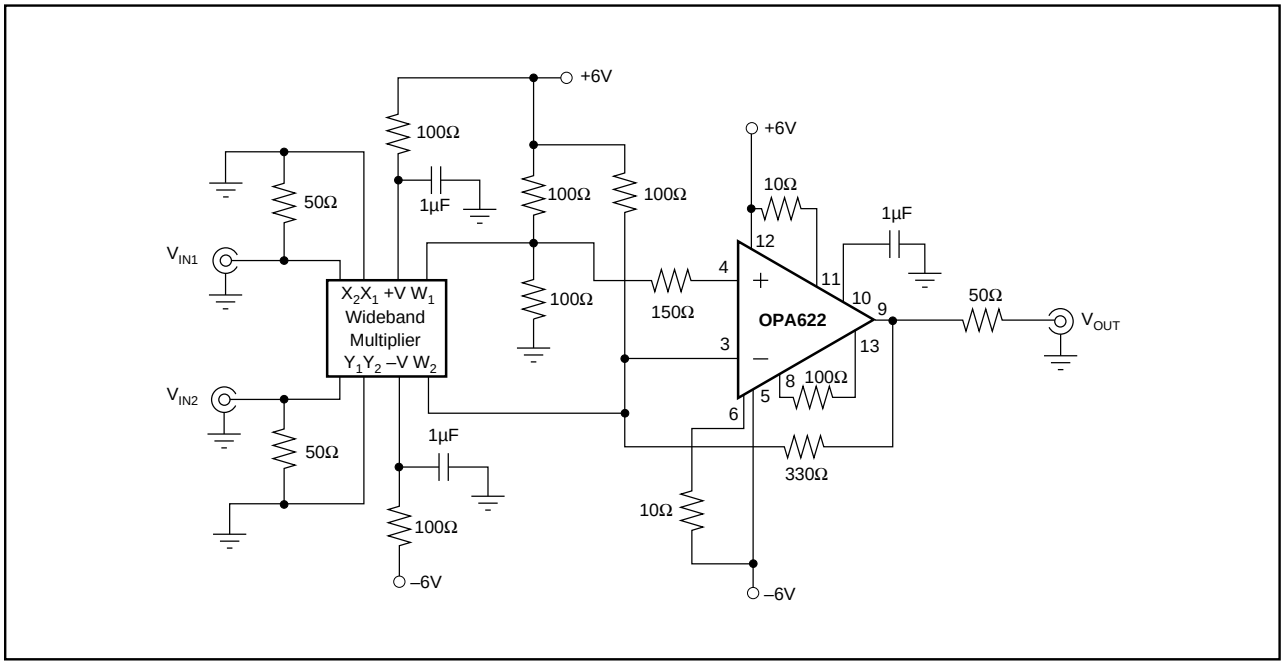


FIGURE 19. Wideband Multiplier Output Amplifier.

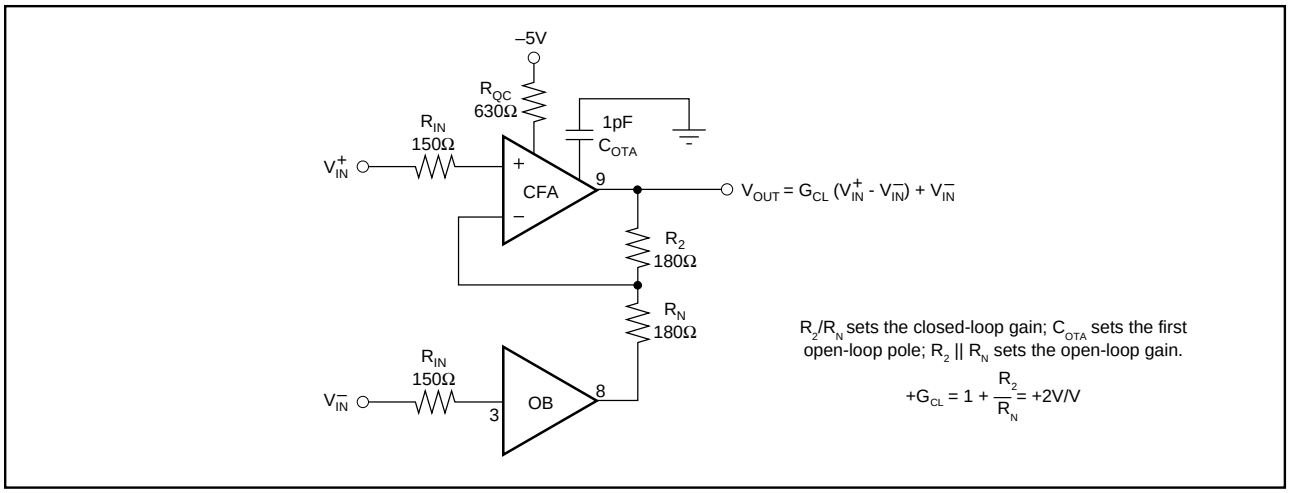


FIGURE 20. Current-Feedback Amplifier with Two Equal and High Impedance Inputs.