

OPA658

## Wideband, Low Power Current Feedback OPERATIONAL AMPLIFIER

### FEATURES

- UNITY GAIN STABLE BANDWIDTH: 900MHz
- LOW POWER: 50mW
- LOW DIFFERENTIAL GAIN/PHASE ERRORS: 0.025%/0.02°
- HIGH SLEW RATE: 1700V/ $\mu$ s
- GAIN FLATNESS: 0.1dB to 135MHz
- HIGH OUTPUT CURRENT (80mA)

### APPLICATIONS

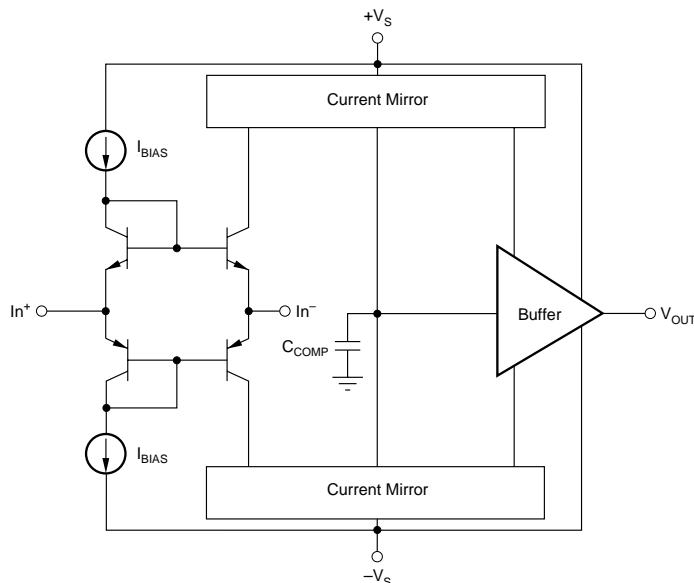
- MEDICAL IMAGING
- HIGH-RESOLUTION VIDEO
- HIGH-SPEED SIGNAL PROCESSING
- COMMUNICATIONS
- PULSE AMPLIFIERS
- ADC/DAC GAIN AMPLIFIER
- MONITOR PREAMPLIFIER
- CCD IMAGING AMPLIFIER

### DESCRIPTION

The OPA658 is an ultra-wideband, low power current feedback video operational amplifier featuring high slew rate and low differential gain/phase error. The current feedback design allows for superior large signal bandwidth, even at high gains. The low differential gain/phase errors, wide bandwidth and low quiescent

current make the OPA658 a perfect choice for numerous video, imaging and communications applications.

The OPA658 is optimized for low gain operation and is also available in dual (OPA2658) and quad (OPA4658) configurations.



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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

# SPECIFICATIONS

At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 5\text{V}$ ,  $R_L = 100\Omega$ , and  $R_{FB} = 402\Omega$ , unless otherwise noted.

PARAMETER	CONDITION	OPA658P, U, N			OPA658UB, NB			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
<b>FREQUENCY RESPONSE</b>								
Closed-Loop Bandwidth <sup>(2)</sup>	$G = +1^{(4)}$		900			* <sup>(1)</sup>		MHz
	$G = +2$		680		400	*		MHz
	$G = +5$		370			*		MHz
	$G = +10$		200			*		MHz
Slew Rate <sup>(3)</sup>	$G = +2, 2\text{V Step}$		1700		1000	*		V/ $\mu\text{s}$
At Minimum Specified Temperature			1500		900	*		V/ $\mu\text{s}$
Settling Time: 0.01%	$G = +2, 2\text{V Step}$		15			*		ns
0.1%	$G = +2, 2\text{V Step}$		11.5			*		ns
1%	$G = +2, 2\text{V Step}$		6			*		ns
Spurious Free Dynamic Range	$f = 5\text{MHz}, G = +2, V_O = 2\text{Vp-p}$		68			*		dBc
	$f = 20\text{MHz}, G = +2, V_O = 2\text{Vp-p}$		56			*		dBc
Third Order Intercept Point	$f = 10\text{MHz}, 4\text{dBm Each Tone}$		40			*		dBm
Differential Gain	$G = +2, \text{NTSC}, V_O = 1.4\text{Vp-p}, R_L = 150\Omega$		0.025			*		%
Differential Phase	$G = +2, \text{NTSC}, V_O = 1.4\text{Vp-p}, R_L = 150\Omega$		0.02			*		degrees
Bandwidth for 0.1dB Flatness	$G = +2$		135 <sup>(5)</sup>			*		MHz
<b>OFFSET VOLTAGE</b>								
Input Offset Voltage	$V_{CM} = 0\text{V}$		$\pm 3$	$\pm 5.5$		$\pm 2$	$\pm 4.5$	mV
Over Temperature Range			$\pm 5$	$\pm 8$		$\pm 4$	$\pm 7$	mV
Power Supply Rejection Ratio	$V_S = \pm 4.7 \text{ to } \pm 5.5\text{V}$	55	64		58	67		dB
<b>INPUT BIAS CURRENT</b>								
Non-Inverting	$V_{CM} = 0\text{V}$		$\pm 5.7$	$\pm 30$		*	$\pm 18$	$\mu\text{A}$
Over Temperature Range			$\pm 10$	$\pm 80$		*	$\pm 35$	$\mu\text{A}$
Inverting	$V_{CM} = 0\text{V}$		$\pm 1.1$	$\pm 35$		*	*	$\mu\text{A}$
Over Temperature Range			$\pm 30$	$\pm 75$		*	*	$\mu\text{A}$
<b>NOISE</b>								
Input Voltage Noise Density								
$f = 100\text{Hz}$			16			*		nV/ $\sqrt{\text{Hz}}$
$f = 2\text{kHz}$			4.9			*		nV/ $\sqrt{\text{Hz}}$
$f = 10\text{kHz}$			3.2			*		nV/ $\sqrt{\text{Hz}}$
$f = 1\text{MHz}$			3.2			*		nV/ $\sqrt{\text{Hz}}$
$f_B = 100\text{Hz to } 200\text{MHz}$			45.3			*		$\mu\text{Vrms}$
Input Bias Current Noise Density								
Inverting: $f = 1\text{MHz}$			32			*		pA/ $\sqrt{\text{Hz}}$
Non-Inverting: $f = 1\text{MHz}$			11.9			*		pA/ $\sqrt{\text{Hz}}$
<b>INPUT VOLTAGE RANGE</b>								
Common-Mode Input Range								
Over Temperature Range			$\pm 2.5$	$\pm 2.9$		*	*	V
Common-Mode Rejection	$V_{CM} = \pm 1\text{V}$		45	50		*	*	dB
<b>INPUT IMPEDANCE</b>								
Non-Inverting				500    1		*		k $\Omega$    pF
Inverting				50		*		$\Omega$
<b>OPEN-LOOP TRANSRESISTANCE</b>								
Open-Loop Transresistance	$V_O = \pm 2\text{V}, R_L = 100\Omega$	150	190		200	250		k $\Omega$
Over Temperature Range	$V_O = \pm 2\text{V}, R_L = 100\Omega$	100			150			k $\Omega$
<b>OUTPUT</b>								
Voltage Output	No Load		$\pm 2.7$	$\pm 2.9$		*	*	V
Over Temperature Range			$\pm 2.5$	$\pm 2.75$		*	*	V
Voltage Output	$R_L = 250\Omega$		$\pm 2.7$	$\pm 2.9$		*	*	V
Over Temperature Range			$\pm 2.5$	$\pm 2.7$		*	*	V
Voltage Output	$R_L = 100\Omega$		$\pm 2.2$	$\pm 2.8$		*	*	V
Over Temperature Range			$\pm 2.0$	$\pm 2.5$		*	*	V
Output Current, Sourcing		80	120		*	*		mA
Over Temperature		70			*	*		mA
Output Current, Sinking		60	80		*	*		mA
Over Temperature		35			*	*		mA
Short Circuit Current			150			*		mA
Output Resistance	0.1MHz, $G = +2$		0.02			*		$\Omega$
<b>POWER SUPPLY</b>								
Specified Operating Voltage			$\pm 5$			*	*	V
Operating Voltage Range		$\pm 4.5$		$\pm 5.5$		*	*	V
Quiescent Current	$V_S = \pm 5\text{V}$		$\pm 5$	$\pm 7.75$		$\pm 4.5$	$\pm 5.75$	mA
Over Temperature Range			$\pm 5.5$	$\pm 8.5$		$\pm 4.7$	$\pm 6.5$	mA
<b>TEMPERATURE RANGE</b>								
Specification: P, U, N, UB, NB		-40		+85		*	*	$^\circ\text{C}$
Thermal Resistance, $\theta_{JA}$								
P 8-Pin DIP		100				*	$^\circ\text{C/W}$	
U SO-8		125				*	$^\circ\text{C/W}$	
N SOT23-5		150				*	$^\circ\text{C/W}$	

NOTES: (1) An asterisk (\*) specifies the same value as the grade to the left. (2) Frequency response can be strongly influenced by PC board parasitics. The demonstration boards show low parasitic layouts for this part. Refer to the demonstration board layout for details. (3) Slew rate is rate of change from 10% to 90% of output voltage step. (4) At  $G = +1$ ,  $R_{FB} = 560\Omega$  for PDIP and  $402\Omega$  for SO-8. (5) This specification is PC board layout dependent.

## ABSOLUTE MAXIMUM RATINGS

Supply .....	±5.5V
Internal Power Dissipation .....	See Thermal Considerations
Differential Input Voltage .....	±1.2V
Input Voltage Range .....	±V <sub>S</sub>
Storage Temperature Range: P, U, UB, N, NB .....	-40°C to +125°C
Lead Temperature (soldering, 10s) .....	+300°C
(soldering, SOIC 3s) .....	+260°C
Junction Temperature (T <sub>J</sub> ) .....	+175°C

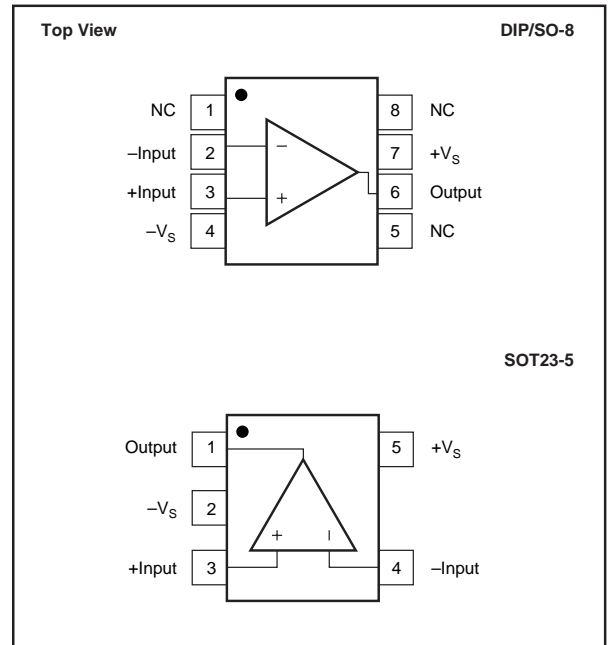


## ELECTROSTATIC DISCHARGE SENSITIVITY

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.

## PIN CONFIGURATION



## PACKAGE/ORDERING INFORMATION

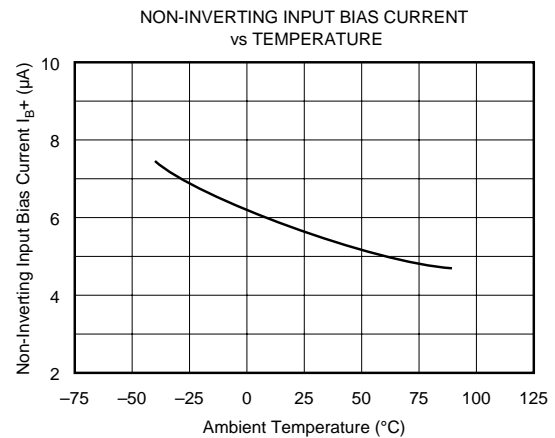
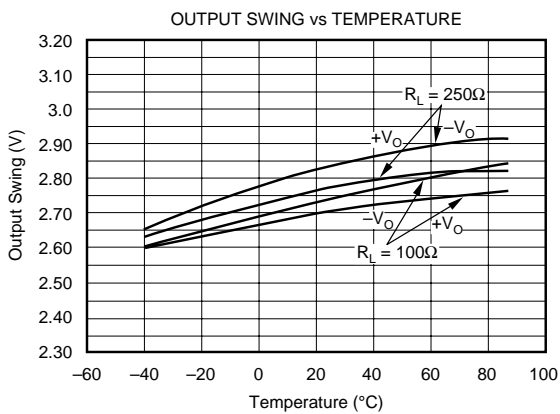
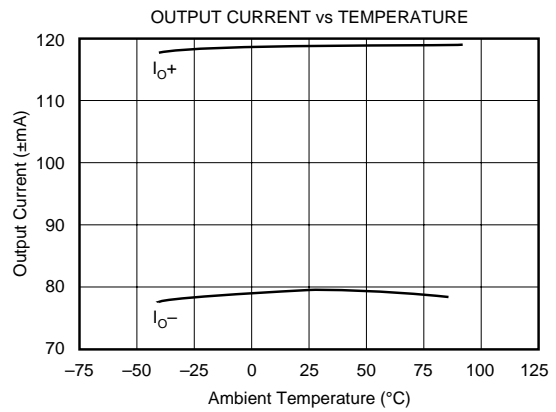
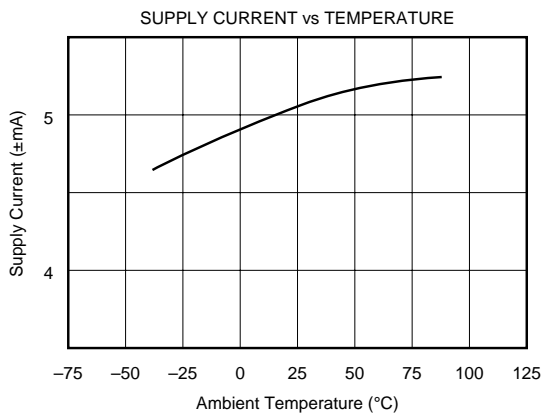
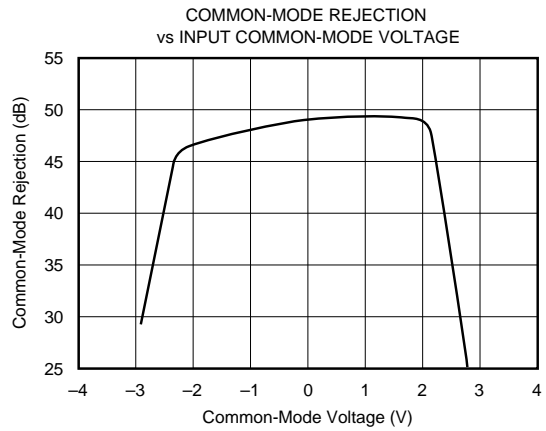
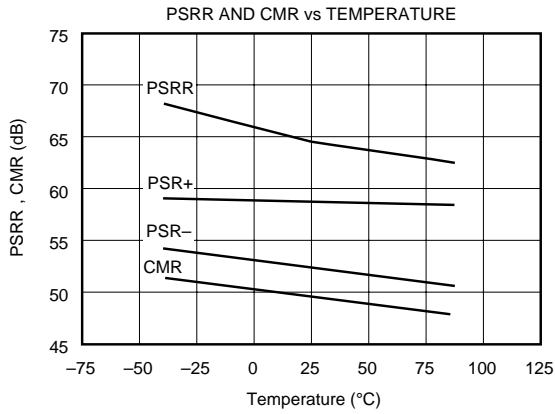
PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER <sup>(1)</sup>	TEMPERATURE RANGE	PACKAGE MARKING <sup>(2)</sup>	ORDERING NUMBER <sup>(3)</sup>
OPA658U	SO-8 Surface Mount	182	-40°C to +85°C	OPA658U	OPA658U
OPA658UB	SO-8 Surface Mount	182	-40°C to +85°C	OPA658UB	OPA658UB
OPA658N	5-pin SOT23-5	331	-40°C to +85°C	A58	OPA658N-250 OPA658N-3k
OPA658NB	5-pin SOT23-5	331	-40°C to +85°C	A58B	OPA658NB-250 OPA658NB-3k
OPA658P	8-Pin Plastic DIP	006	-40°C to +85°C	OPA658P	OPA658P

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book. (2) The "B" grade of the SO-8 will be marked with a "B" by pin 8. The "B" grade of the SOT23-5 will be marked with a "B" near pins 3 and 4. (3) The SOT23-5 is only available on a 7" tape and reel (e.g. ordering 250 pieces of "OPA658N-250" will get a single 250 piece tape and reel. Ordering 3000 pieces of "OPA658N-3k" will get a single 3000 piece tape and reel). Please refer to Appendix B of Burr-Brown IC Data Book for detailed Tape and Reel Mechanical information.

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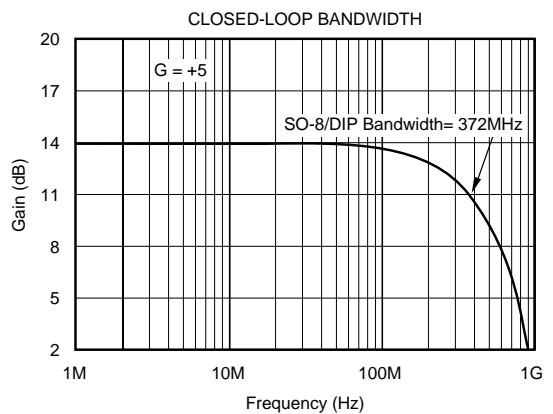
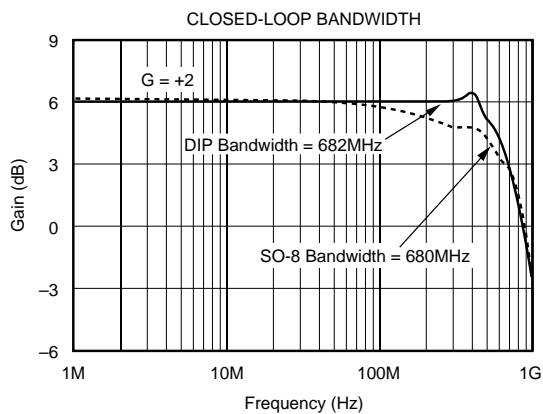
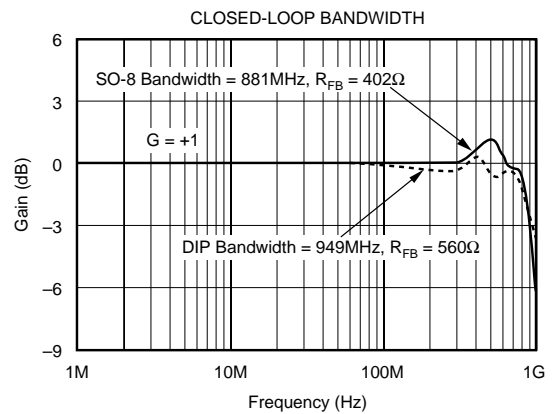
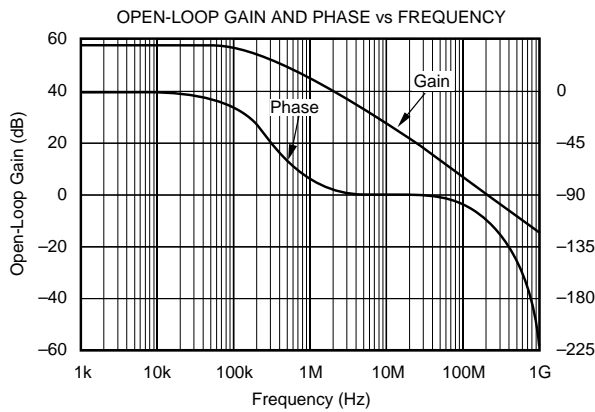
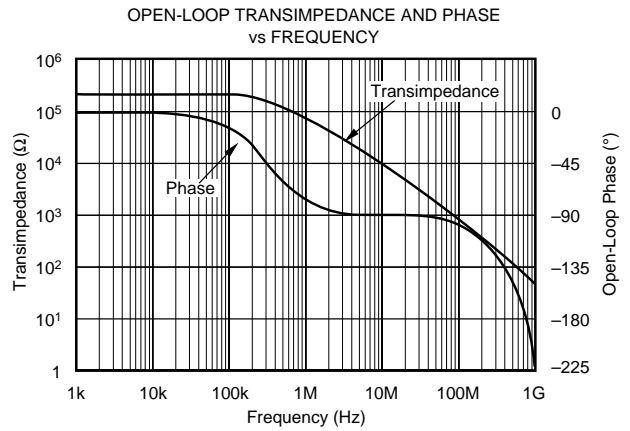
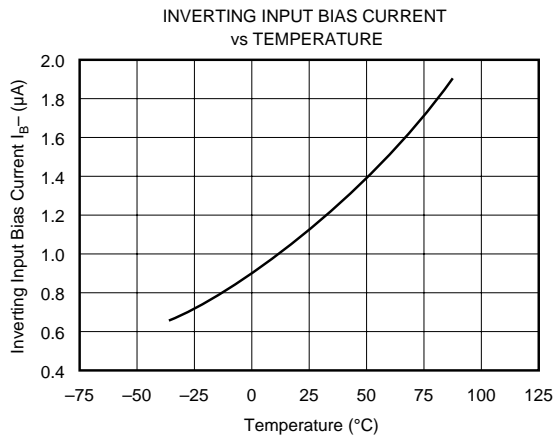
# TYPICAL PERFORMANCE CURVES

At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 5\text{V}$ ,  $R_L = 100\Omega$ , and  $R_{FB} = 402\Omega$ , unless otherwise noted.



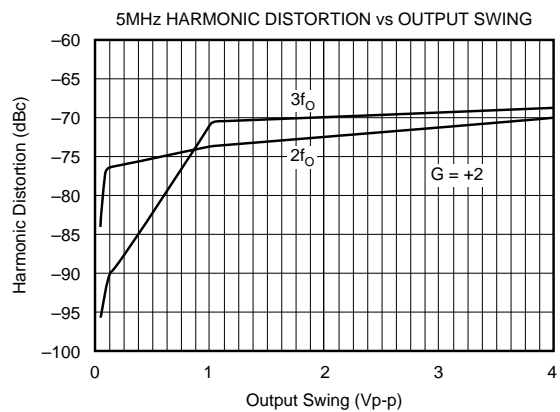
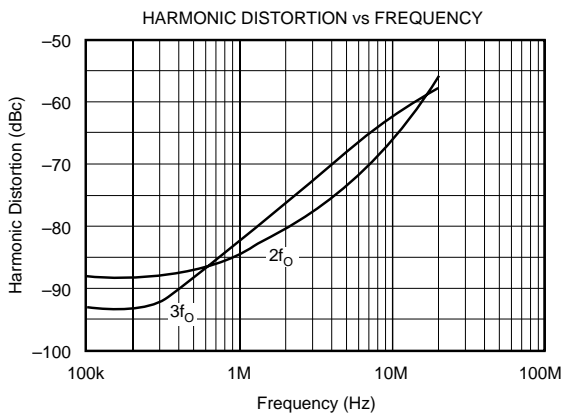
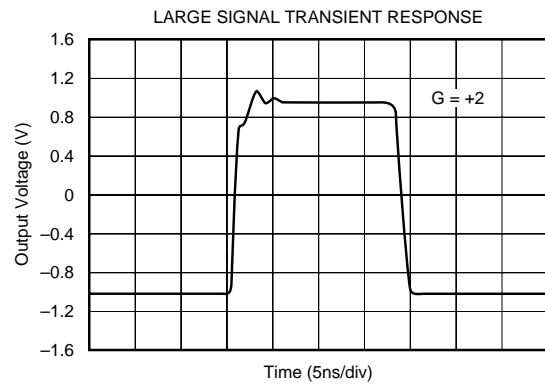
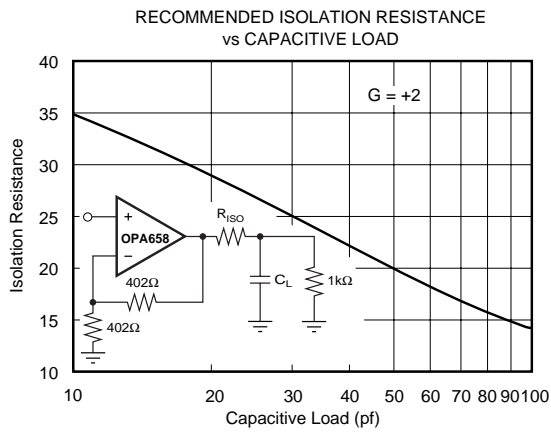
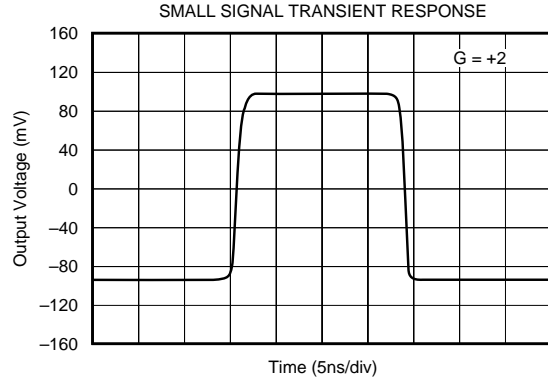
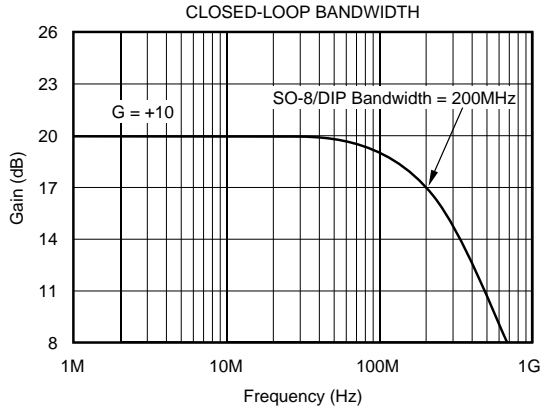
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At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 5\text{V}$ ,  $R_L = 100\Omega$ , and  $R_{FB} = 402\Omega$ , unless otherwise noted.



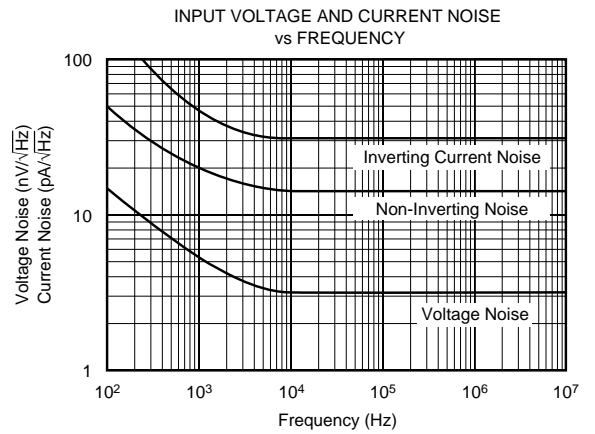
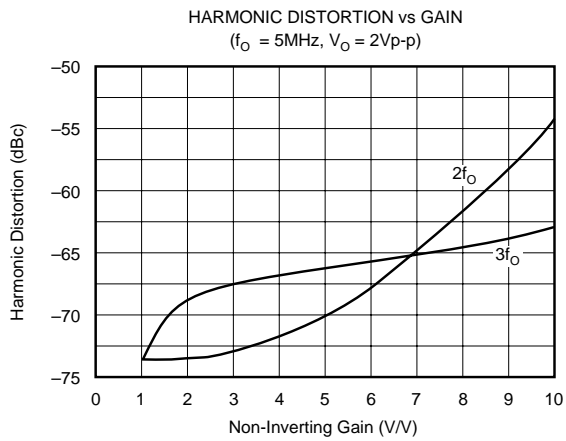
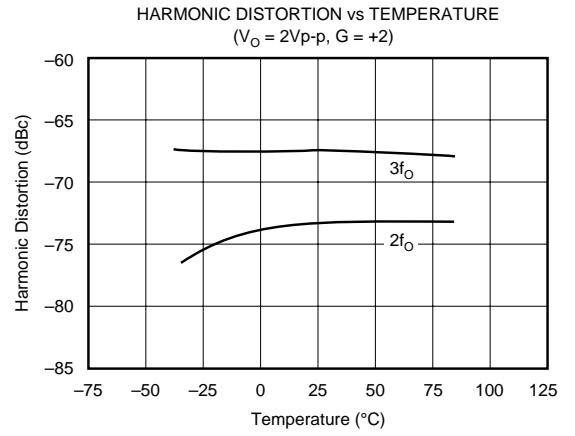
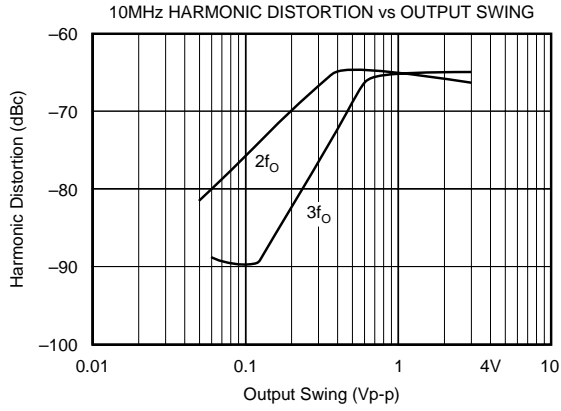
# TYPICAL PERFORMANCE CURVES (CONT)

At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 5\text{V}$ ,  $R_L = 100\Omega$ , and  $R_{FB} = 402\Omega$ , unless otherwise noted.



# TYPICAL PERFORMANCE CURVES (CONT)

At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 5\text{V}$ ,  $R_L = 100\Omega$ , and  $R_{FB} = 402\Omega$ , unless otherwise noted.



# APPLICATIONS INFORMATION

## THEORY OF OPERATION

Conventional op amps depend on feedback to drive their inputs to the same potential, however the current feedback op amp's inverting and non-inverting inputs are connected by a unity gain buffer, thus enabling the inverting input to automatically assume the same potential as the non-inverting input. This results in very low impedance at the inverting input to sense the feedback as an error current signal.

## DISCUSSION OF PERFORMANCE

The OPA658 is a low-power, unity gain stable, current feedback operational amplifier which operates on  $\pm 5V$  power supply. The current feedback architecture offers the following important advantages over voltage feedback architectures: (1) the high slew rate allows the large signal performance to approach the small signal performance, and (2) there is very little bandwidth degradation at higher gain settings.

The current feedback architecture of the OPA658 provides the traditional strength of excellent large signal response plus wide bandwidth, making it a good choice for use in high resolution video, medical imaging and DAC I/V Conversion. The low power requirements make it an excellent choice for numerous portable applications.

## DC GAIN TRANSFER CHARACTERISTICS

The circuit in Figure 1 shows the equivalent circuit for calculating the DC gain. When operating the device in the inverting mode, the input signal error current ( $I_E$ ) is amplified by the open loop transimpedance gain ( $T_O$ ). The output signal generated is equal to  $T_O \times I_E$ . Negative feedback is applied through  $R_{FB}$  such that the device operates at a gain equal to  $-R_{FB}/R_{FF}$ .

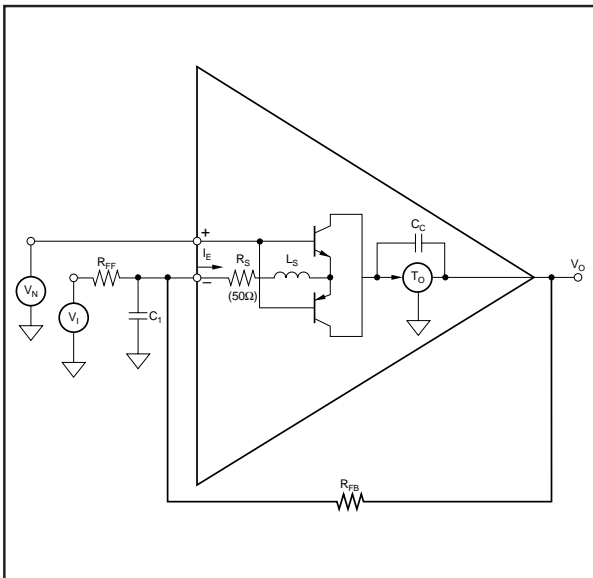


FIGURE 1. Equivalent Circuit.

For non-inverting operation, the input signal is applied to the non-inverting (high impedance buffer) input. The output (buffer) error current ( $I_E$ ) is generated at the low impedance inverting input. The signal generated at the output is fed back to the inverting input such that the overall gain is  $(1 + R_{FB}/R_{FF})$ . Where a voltage-feedback amplifier has two symmetrical high impedance inputs, a current feedback amplifier has a low inverting (buffer output) impedance and a high non-inverting (buffer input) impedance.

The closed-loop gain for the OPA658 can be calculated using the following equations:

$$\text{Inverting Gain} = \frac{-\left(\frac{R_{FB}}{R_{FF}}\right)}{1 + \frac{1}{\text{Loop Gain}}} \quad (1)$$

$$\text{Non-Inverting Gain} = \frac{\left[1 + \frac{R_{FB}}{R_{FF}}\right]}{1 + \frac{1}{\text{Loop Gain}}} \quad (2)$$

$$\text{where Loop Gain} = \left[ \frac{T_O}{R_{FB} + R_S \left(1 + \frac{R_{FB}}{R_{FF}}\right)} \right]$$

At higher gains the small value inverting input impedance causes an apparent loss in bandwidth. This can be seen from the equation:

$$f_{\text{ACTUAL BW}} \approx \left[ f_{(A_V=+2)} \text{ BW} \right] \times (1.25) \quad (3)$$

$$\left[ 1 + \left( \frac{R_S}{R_{FB}} \right) \times \left( 1 + \frac{R_{FB}}{R_{FF}} \right) \right]$$

This loss in bandwidth at high gains can be corrected without affecting stability by lowering the value of the feedback resistor from the specified value of 402Ω.

## OFFSET VOLTAGE AND NOISE

The output offset is the algebraic sum of the input offset voltage and bias current errors. The output offset for non-inverting operation is calculated by the following equation:

$$\text{Output Offset Voltage} = \pm I_{b_N} \times R_N \left( 1 + \frac{R_{FB}}{R_{FF}} \right) \pm \quad (4)$$

$$V_{IO} \left( 1 + \frac{R_{FB}}{R_{FF}} \right) \pm I_{b_I} \times R_{FB}$$

If all terms are divided by the gain  $(1 + R_{FB}/R_{FF})$  it can be observed that input referred offsets improve as gain increases. The effective noise at the output can be determined by taking

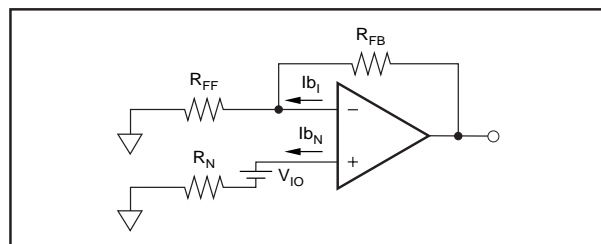


FIGURE 2. Output Offset Voltage Equivalent Circuit.



the root sum of the squares of equation (4) and applying the spectral noise values found in the Typical Performance Curve graph section. This applies to noise from the op amp only. Note that both the noise figure (NF) and the equivalent input offset voltages improve as the closed loop gain increases (by keeping  $R_{FB}$  fixed and reducing  $R_{FF}$  with  $R_N = 0\Omega$ ).

### INCREASING BANDWIDTH AT HIGH GAINS

The closed-loop bandwidth can be extended at high gains by reducing the value of the feedback resistor  $R_{FB}$ . This bandwidth reduction is caused by the feedback current being split between  $R_S$  and  $R_{FF}$  (refer to Figure 1). As the gain increases (for a fixed  $R_{FB}$ ), more feedback current is shunted through  $R_{FF}$ , which reduces closed-loop bandwidth.

### CIRCUIT LAYOUT AND BASIC OPERATION

Achieving optimum performance with a high frequency amplifier like the OPA658 requires careful attention to layout parasitics and selection of external components. Recommendations for PC board layout and component selection include:

**a) Minimize parasitic capacitance** to any ac ground for all of the signal I/O pins. Parasitic capacitance on the output and inverting input pins can cause instability; on the non-inverting input it can react with the source impedance to cause unintentional bandlimiting. To reduce unwanted capacitance, a window around the signal I/O pins should be opened in all of the ground and power planes. Otherwise, ground and power planes should be unbroken elsewhere on the board.

**b) Minimize the distance** (< 0.25") from the two power pins to high frequency 0.1 $\mu$ F decoupling capacitors. At the pins, the ground and power plane layout should not be in close proximity to the signal I/O pins. Avoid narrow power and ground traces to minimize inductance between the pins and the decoupling capacitors. Larger (2.2 $\mu$ F to 6.8 $\mu$ F) decoupling capacitors, effective at lower frequencies, should also be used. These may be placed somewhat farther from the device and may be shared among several devices in the same area of the PC board.

**c) Careful selection and placement of external components will preserve the high frequency performance of the OPA658.** Resistors should be a very low reactance type. Surface mount resistors work best and allow a tighter overall layout. Metal film or carbon composition axially-leaded resistors can also provide good high frequency performance. Again, keep their leads as short as possible. Never use wirewound type resistors in a high frequency application.

Since the output pin and the inverting input pin are most sensitive to parasitic capacitance, always position the feedback and series output resistor, if any, as close as possible to the package pins. Other network components, such as non-inverting input termination resistors, should also be placed close to the package.

The feedback resistor value acts as the frequency response compensation element for a current feedback type amplifier.

The 402 $\Omega$  used in setting the specification achieves a nominal maximally flat butterworth response while assuming a 2pF output pin parasitic. Increasing the feedback resistor will over compensate the amplifier, rolling off the frequency response, while decreasing it will decrease phase margin, peaking up the frequency response. Note that a non-inverting, unity gain buffer application still requires a feedback resistor for stability (560 $\Omega$  for SO-8, 402 $\Omega$  for PDIP, and 324 $\Omega$  for SOT23).

**d) Connections to other wideband devices** on the board may be made with short direct traces or through on-board transmission lines. For short connections, consider the trace and the input to the next device as a lumped capacitive load. Relatively wide traces (50 to 100 mils) should be used, preferably with ground and power planes opened up around them. Estimate the total capacitive load and set  $R_{ISO}$  from the plot of recommended  $R_{ISO}$  vs capacitive load. Low parasitic loads may not need an  $R_{ISO}$  since the OPA658 is nominally compensated to operate with a 2pF parasitic load.

If a long trace is required and the 6dB signal loss intrinsic to doubly terminated transmission lines is acceptable, implement a matched impedance transmission line using microstrip or stripline techniques (consult an ECL design handbook for microstrip and stripline layout techniques). A 50 $\Omega$  environment is not necessary on board, and in fact a higher impedance environment will improve distortion as shown in the distortion vs load plot. With a characteristic impedance defined based on board material and desired trace dimensions, a matching series resistor into the trace from the output of the amplifier is used as well as a terminating shunt resistor at the input of the destination device. Remember also that the terminating impedance will be the parallel combination of the shunt resistor and the input impedance of the destination device; the total effective impedance should match the trace impedance. Multiple destination devices are best handled as separate transmission lines, each with their own series and shunt terminations.

If the 6dB attenuation loss of a doubly terminated line is unacceptable, a long trace can be series-terminated at the source end only. This will help isolate the line capacitance from the op amp output, but will not preserve signal integrity as well as a doubly terminated line. If the shunt impedance at the destination end is finite, there will be some signal attenuation due to the voltage divider formed by the series and shunt impedances.

**e) Socketing a high speed part like the OPA658 is not recommended.** The additional lead length and pin-to-pin capacitance introduced by the socket creates an extremely troublesome parasitic network which can make it almost impossible to achieve a smooth, stable response. Best results are obtained by soldering the part onto the board. If socketing for the DIP package is desired, high frequency flush mount pins (e.g., McKenzie Technology #710C) can give good results.

The OPA658 is nominally specified for operation using  $\pm 5V$  power supplies. A 10% tolerance on the supplies, or an ECL  $-5.2V$  for the negative supply, is within the maximum

specified total supply voltage of 11V. Higher supply voltages can break down internal junctions possibly leading to catastrophic failure. Single supply operation is possible as long as common mode voltage constraints are observed. The common mode input and output voltage specifications can be interpreted as a required headroom to the supply voltage. Observing this input and output headroom requirement will allow non-standard or single supply operation. Figure 3 shows one approach to single-supply operation.

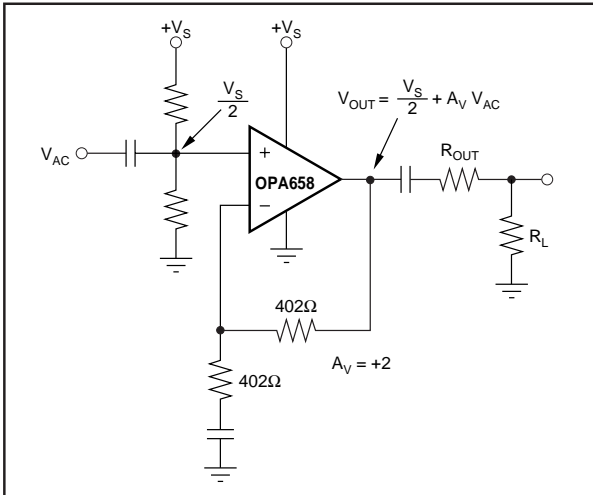


FIGURE 3. Single Supply Operation.

### ESD PROTECTION

ESD static damage has been well recognized for MOSFET devices, but any semiconductor device deserves protection from this potentially damaging source. This is particularly true for very high speed, fine geometry processes.

ESD static damage can cause subtle changes in amplifier input characteristics without necessarily destroying the device. In precision operational amplifiers, this may cause a noticeable degradation of offset voltage and drift. Therefore, static protection is strongly recommended when handling the OPA658.

### OUTPUT DRIVE CAPABILITY

The OPA658 has been optimized to drive 75Ω and 100Ω resistive loads. The device can drive 2V<sub>p-p</sub> into a 75Ω load. This high-output drive capability makes the OPA658 an ideal choice for a wide range of RF, IF, and video applications. In many cases, additional buffer amplifiers are unneeded.

Many demanding high-speed applications such as ADC/DAC buffers require op amps with low wideband output impedance. For example, low output impedance is essential when driving the signal-dependent capacitances at the inputs of flash A/D converters. As shown in Figure 4, the OPA658 maintains very low closed-loop output impedance over frequency. Closed-loop output impedance increases with frequency since loop gain is decreasing with frequency.

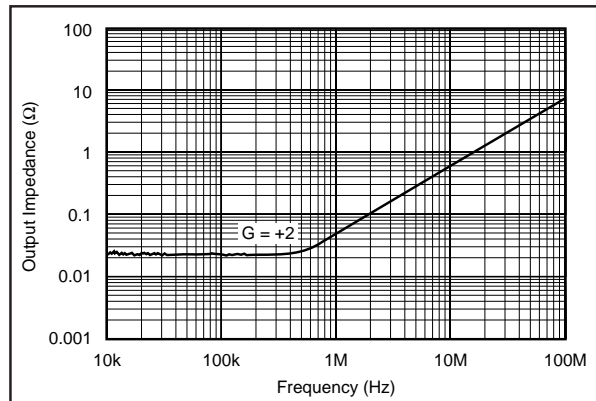


FIGURE 4. Closed-Loop Output Impedance vs Frequency.

### THERMAL CONSIDERATIONS

The OPA658 will not require heatsinking under most operating conditions. Maximum desired junction temperature will set a maximum allowed internal power dissipation as described below. In no case should the maximum junction temperature be allowed to exceed 175°C.

Operating junction temperature ( $T_j$ ) is given by  $T_A + P_D \cdot \theta_{JA}$ . The total internal power dissipation ( $P_D$ ) is the sum of quiescent power ( $P_{DQ}$ ) and additional power dissipated in the output stage ( $P_{DL}$ ) to deliver load power. Quiescent power is simply the specified no-load supply current times the total supply voltage across the part.  $P_{DL}$  will depend on the required output signal and load but would, for a grounded resistive load, be at a maximum when the output is fixed at a voltage equal to 1/2 either supply voltage (for equal bipolar supplies). Under this condition  $P_{DL} = V_S^2 / (4 \cdot R_L)$  where  $R_L$  includes feedback network loading.

Note that it is the power in the output stage and not into the load that determines internal power dissipation.

As an example, compute the maximum  $T_j$  for an OPA658N at  $A_V = +2$ ,  $R_L = 100\Omega$ ,  $R_{FB} = 402\Omega$ ,  $\pm V_S = \pm 5V$ , and the specified maximum  $T_A = +85^\circ C$ .  $P_D = 10V \cdot 8.5mA + 5^2 / [4 \cdot (100\Omega \parallel 804\Omega)] = 155mW$ . Maximum  $T_j = 85^\circ C + 0.155W \cdot 150^\circ C/W = 108^\circ C$ .

### DRIVING CAPACITIVE LOADS

The OPA658's output stage has been optimized to drive low resistive loads. Capacitive loads, however, will decrease the amplifier's phase margin which may cause high frequency peaking or oscillations. Capacitive loads greater than 5pF should be buffered by connecting a small resistance, usually 10Ω to 35Ω, in series with the output as shown in Figure 5. This is particularly important when driving high capacitance loads such as flash A/D converters.

In general, capacitive loads should be minimized for optimum high frequency performance. Coax lines can be driven if the cable is properly terminated. The capacitance of coax cable (29pF/foot for RG-58) will not load the amplifier when the coaxial cable or transmission line is terminated with its characteristic impedance.

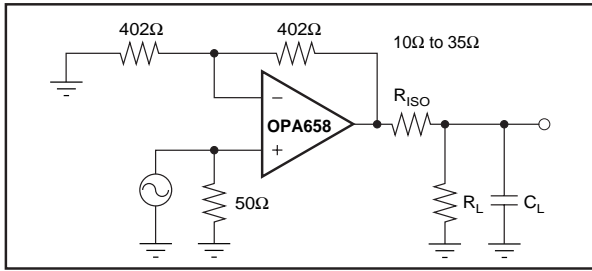


FIGURE 5. Driving Capacitive Loads.

### COMPENSATION

The OPA658 is internally compensated and is stable in unity gain with a phase margin of approximately  $62^\circ$ , and approximately  $64^\circ$  in a gain of  $+2V/V$  when used with the recommended feedback resistor value. Frequency response for other gains are shown in the Typical Performance Curves.

The high-frequency response of the OPA658 in a good layout is very flat with frequency.

### DISTORTION

The OPA658's Harmonic Distortion characteristics into a  $100\Omega$  load are shown versus frequency and power output in the Typical Performance Curves. Distortion can be further improved by increasing the load resistance as illustrated in Figure 6. Remember to include the contribution of the feedback resistance when calculating the effective load resistance seen by the amplifier.

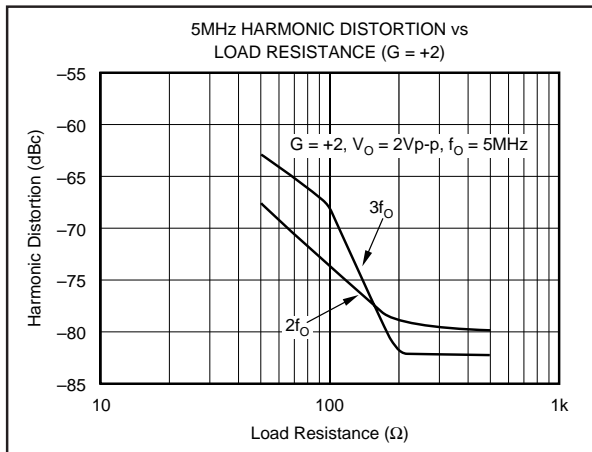


FIGURE 6. 5MHz Harmonic Distortion vs Load Resistance.

Narrowband communication channel requirements will benefit from the OPA658's wide bandwidth and low intermodulation distortion on low quiescent power. If output signal power at two closely spaced frequencies is required, third-order nonlinearities in any amplifier will cause spurious power at frequencies very near the two fundamental frequencies. If the two test frequencies,  $f_1$  and  $f_2$ , are specified in terms of average and delta frequency,  $f_0 = (f_1 + f_2)/2$  and  $\Delta f = |f_2 - f_1|$ , the two, third-order,

close-in spurious tones will appear at  $f_0 \pm 3 \cdot \Delta f$ . The two tone, third-order spurious plot shown in Figure 7 indicates how far below these two equal power, closely spaced, tones the intermodulation spurious will be. The single tone power is at a matched  $50\Omega$  load. The unique design of the OPA658 provides much greater spurious free range than what a two-tone third-order intermodulation intercept specification would predict. This can be seen in Figure 7 as the spurious free range actually increases at the higher output power levels.

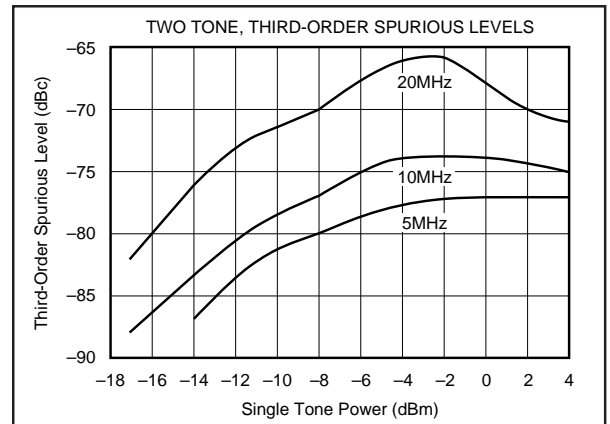


FIGURE 7. Third-Order Spurious Level vs Frequency.

### DIFFERENTIAL GAIN AND PHASE

Differential Gain (dG) and Differential Phase (dP) are among the more important specifications for video applications. dG is defined as the percent change in closed-loop gain over a specified change in output voltage level. dP is defined as the change in degrees of the closed-loop phase over the same output voltage change. Both dG and dP are specified at the NTSC sub-carrier frequency of  $3.58\text{MHz}$  and the PAL sub-carrier of  $4.43\text{MHz}$ . All NTSC measurements were performed using a Tektronix model VM700A Video Measurement Set.

dG/dP of the OPA658 were measured with the amplifier in a gain of  $+2V/V$  with  $75\Omega$  input impedance and the output back-terminated in  $75\Omega$ . The input signal selected from the generator was a  $0V$  to  $1.4V$  modulated ramp with sync pulse. With these conditions the test circuit shown in Figure 8 delivered a  $100\text{IRE}$  modulated ramp to the  $75\Omega$  input of the videoanalyzer. The signal averaging feature of the analyzer

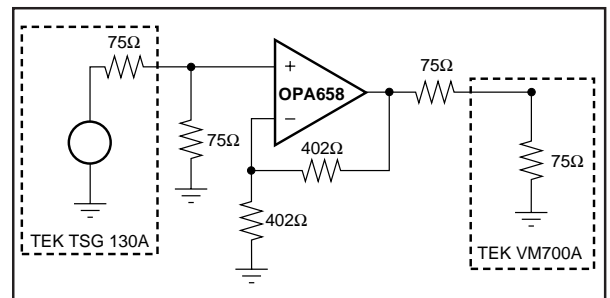


FIGURE 8. Configuration for Testing Differential Gain/Phase.

was used to establish a reference against which the performance of the amplifier was measured. Signal averaging was also used to measure the dg and dp of the test signal in order to eliminate the generator's contribution to measured amplifier performance. Typical performance of the OPA658 is 0.025% differential gain and 0.02° differential phase to both NTSC and PAL standards.

### SPICE MODELS AND EVALUATION BOARDS

Computer simulation of circuit performance using SPICE is often useful when analyzing the performance of analog circuits and systems. This is particularly true for Video and RF amplifier circuits where parasitic capacitance and inductance can have a major effect on circuit performance. SPICE models are available on a disk from the Burr-Brown Applications Department.

Demonstration boards are available for each OPA658 package style. These boards implement a very low parasitic layout that will produce the excellent frequency and pulse responses shown in the Typical Performance Curves. For each package style, the recommended demonstration board is:

DEM-OPA65xP	8-Pin DIP for the OPA658P
DEM-OPA65xU	SO-8 for the OPA658U
DEM-OPA6xxN	SOT23 for the OPA658N

Contact your local Burr-Brown sales office or distributor to order demonstration boards.

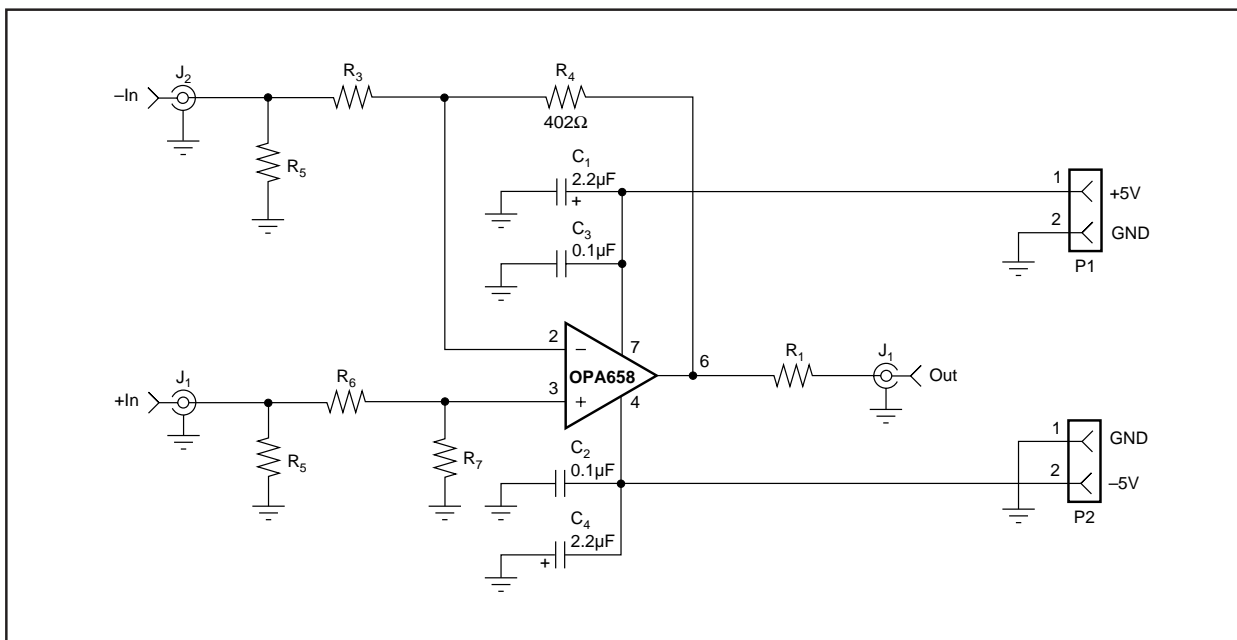
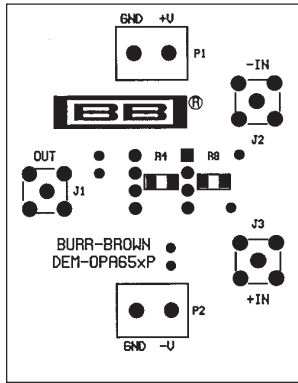
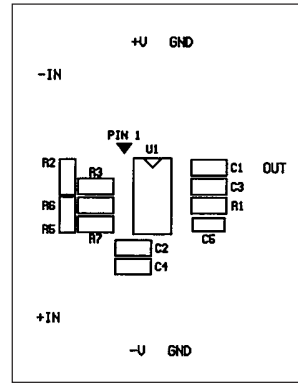


FIGURE 9. Layout Detail For DEM-OPA65xP Demonstration Board.

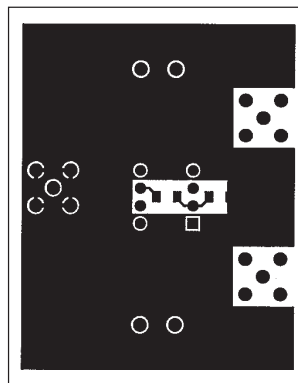
### DEM-OPA65xP Demonstration Board Layout



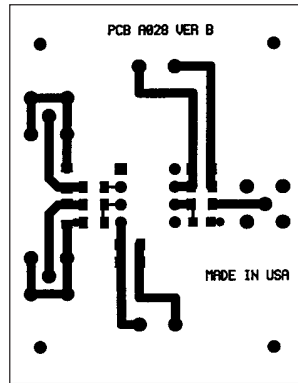
(A)



(B)



(C)



(D)

FIGURE 10a. Evaluation Board Silkscreen (Bottom). 10b. Evaluation Board Silkscreen (Top). 10c. Evaluation Board Layout (Solder Side). 10d. Evaluation Board Layout (Layout Side).

### TYPICAL APPLICATION

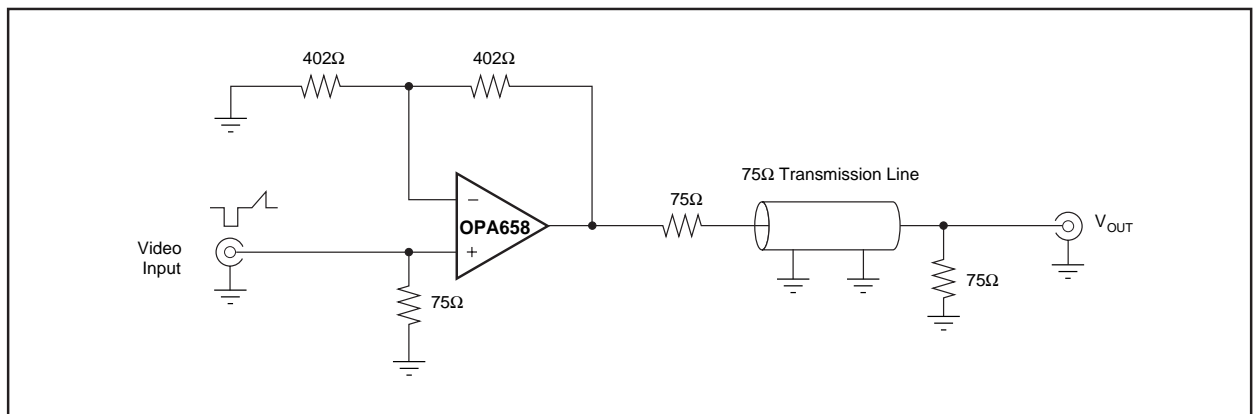


FIGURE 11. Low Distortion Video Amplifier.