

Ultra High-Speed Programmable Gain Buffer Amplifier

July 1995

Features

- User Programmable for Closed-Loop Gains of +1, -1 or +2 without Use of External Resistors
- Wide -3dB Bandwidth 850MHz
- Very Fast Slew Rate..... 2400V/ μ s
- Fast Settling Time (0.1%) 11ns
- High Output Current 60mA
- Excellent Gain Accuracy..... 0.99V/V
- Overdrive Recovery..... <10ns
- Standard Operational Amplifier Pinout

Applications

- RF/IF Processors
- Driving Flash A/D Converters
- High-Speed Communications
- Impedance Transformation
- Line Driving
- Video Switching and Routing
- Radar Systems
- Medical Imaging Systems

Description

The HFA1112 is a closed loop Buffer featuring user programmable gain and ultra high speed performance. Manufactured on Harris' proprietary complementary bipolar UHF-1 process, the HFA1112 offers a wide -3dB bandwidth of 850MHz, very fast slew rate, excellent gain flatness, low distortion and high output current.

A unique feature of the pinout allows the user to select a voltage gain of +1, -1, or +2, without the use of any external components. Gain selection is accomplished via connections to the inputs, as described in the "Application Information" section. The result is a more flexible product, fewer part types in inventory, and more efficient use of board space.

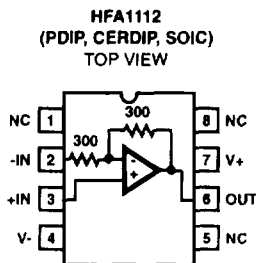
Compatibility with existing op amp pinouts provides flexibility to upgrade low gain amplifiers, while decreasing component count. Unlike most buffers, the standard pinout provides an upgrade path should a higher closed loop gain be needed at a future date.

This amplifier is available with programmable output clamps as the HFA1113. For applications requiring a standard buffer pinout, please refer to the HFA1110 datasheet. For Military product, refer to the HFA1112/883 data sheet.

Ordering Information

| PART NUMBER | TEMPERATURE RANGE | PACKAGE |
|---------------|-------------------|-------------------------|
| HFA1112MJ/883 | -55°C to +125°C | 8 Lead CerDIP |
| HFA1112IJ | -40°C to +85°C | 8 Lead CerDIP |
| HFA1112IP | -40°C to +85°C | 8 Lead Plastic DIP |
| HFA1112IB | -40°C to +85°C | 8 Lead Plastic SOIC (N) |

Pinout



Pin Descriptions

| NAME | PIN NUMBER | DESCRIPTION |
|------|------------|---------------------|
| NC | 1, 5, 8 | No Connection |
| -IN | 2 | Inverting Input |
| +IN | 3 | Non-Inverting Input |
| V- | 4 | Negative Supply |
| OUT | 6 | Output |
| V+ | 7 | Positive Supply |

Specifications HFA1112

Absolute Maximum Ratings

| | |
|---|---------------------|
| Voltage Between V+ and V- | 12V |
| Input Voltage | V _{SUPPLY} |
| Differential Input Voltage | 5V |
| Output Current | 60mA |
| Junction Temperature (Ceramic and Die) | +175°C |
| Junction Temperature (Plastic Package) | +150°C |
| Lead Temperature (Soldering 10s) (SOIC - Lead Tips Only) | +300°C |

Operating Conditions

| | | | |
|--|--|-----------------|-----|
| Operating Temperature Range | HFA1112I: -40°C ≤ T _A ≤ +85°C | | |
| Storage Temperature | -65°C ≤ T _A ≤ +150°C | | |
| Thermal Package Characteristics (°C/W) | θ _{JA} | θ _{JC} | |
| | CerDIP Package | 116 | 36 |
| | Plastic DIP Package | 98 | N/A |
| | SOIC Package | 170 | N/A |

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

Electrical Specifications V_{SUPPLY} = ±5V, A_V = +1, R_L = 100Ω, Unless Otherwise Specified

| PARAMETER | TEMPERATURE | HFA1112I | | | UNITS |
|--|--------------|----------|-------|-------|--------|
| | | MIN | TYP | MAX | |
| INPUT CHARACTERISTICS | | | | | |
| Output Offset Voltage | +25°C | - | 8 | 25 | mV |
| | Full | - | - | 35 | mV |
| Output Offset Voltage Drift | Full | - | 10 | - | μV/°C |
| PSRR | +25°C | 39 | 45 | - | dB |
| | Full | 35 | - | - | dB |
| Input Noise Voltage (100kHz, Note 2) | +25°C | - | 9 | - | nV/√Hz |
| Non-Inverting Input Noise Current (100kHz, Note 2) | +25°C | - | 37 | - | pA/√Hz |
| Non-Inverting Input Bias Current | +25°C | - | 25 | 40 | μA |
| | Full | - | - | 65 | μA |
| Non-Inverting Input Resistance | +25°C | 25 | 50 | - | kΩ |
| Inverting Input Resistance (Note 1) | +25°C | 240 | 300 | 360 | Ω |
| Input Capacitance (Either Input) | +25°C | - | 2 | - | pF |
| Input Common Mode Range | Full | ±2.5 | ±2.8 | - | V |
| TRANSFER CHARACTERISTICS | | | | | |
| Gain (A _V = +1, V _{IN} = +2V) | +25°C | 0.980 | 0.990 | 1.020 | V/V |
| | Full | 0.975 | - | 1.025 | V/V |
| Gain (A _V = +2, V _{IN} = +1V) | +25°C | 1.96 | 1.98 | 2.04 | V/V |
| | Full | 1.95 | - | 2.05 | V/V |
| DC Non-Linearity (A _V = +2, ±2V Full Scale, Note 2) | +25°C | - | 0.02 | - | % |
| OUTPUT CHARACTERISTICS | | | | | |
| Output Voltage (A _V = -1, Note 2) | +25°C | ±3.0 | ±3.3 | - | V |
| | Full | ±2.5 | ±3.0 | - | V |
| Output Current (R _L = 50Ω, Note 2) | +25°C, +85°C | 50 | 60 | - | mA |
| | -40°C | 35 | 50 | - | mA |
| DC Closed Loop Output Impedance (A _V = +2) | +25°C | - | 0.3 | - | Ω |
| POWER SUPPLY CHARACTERISTICS | | | | | |
| Supply Voltage Range | Full | ±4.5 | - | ±5.5 | V |
| Supply Current (Note 2) | +25°C | - | 21 | 26 | mA |
| | Full | - | - | 33 | mA |

Specifications HFA1112

Electrical Specifications $V_{SUPPLY} = \pm 5V$, $A_V = +1$, $R_L = 100\Omega$, Unless Otherwise Specified (Continued)

| PARAMETER | TEMPERATURE | HFA1112I | | | UNITS | |
|---|-------------|----------|------|-------------|------------|------------|
| | | MIN | TYP | MAX | | |
| AC CHARACTERISTICS | | | | | | |
| -3dB Bandwidth ($V_{OUT} = 0.2V_{P.P.}$, Notes 1, 2) | $A_V = -1$ | +25°C | 450 | 800 | - | MHz |
| | $A_V = +1$ | +25°C | 500 | 850 | - | MHz |
| | $A_V = +2$ | +25°C | 350 | 550 | - | MHz |
| Slew Rate ($V_{OUT} = 5V_{P.P.}$, Note 1) | $A_V = -1$ | +25°C | 1500 | 2400 | - | V/ μ s |
| | $A_V = +1$ | +25°C | 800 | 1500 | - | V/ μ s |
| | $A_V = +2$ | +25°C | 1100 | 1900 | - | V/ μ s |
| Full Power Bandwidth ($V_{OUT} = 5V_{P.P.}$, Note 2) | $A_V = -1$ | +25°C | - | 300 | - | MHz |
| | $A_V = +1$ | +25°C | - | 150 | - | MHz |
| | $A_V = +2$ | +25°C | - | 220 | - | MHz |
| Gain Flatness (to 30MHz, Notes 1, 2) | $A_V = -1$ | +25°C | - | ± 0.02 | - | dB |
| | $A_V = +1$ | +25°C | - | ± 0.1 | - | dB |
| | $A_V = +2$ | +25°C | - | ± 0.015 | ± 0.04 | dB |
| Gain Flatness (to 50MHz, Notes 1, 2) | $A_V = -1$ | +25°C | - | ± 0.05 | - | dB |
| | $A_V = +1$ | +25°C | - | ± 0.2 | - | dB |
| | $A_V = +2$ | +25°C | - | ± 0.036 | ± 0.08 | dB |
| Gain Flatness (to 100MHz, Notes 1, 2) | $A_V = -1$ | +25°C | - | ± 0.10 | - | dB |
| | $A_V = +2$ | +25°C | - | ± 0.07 | ± 0.22 | dB |
| Linear Phase Deviation (to 100MHz, Note 2) | $A_V = -1$ | +25°C | - | ± 0.13 | - | Degrees |
| | $A_V = +1$ | +25°C | - | ± 0.83 | - | Degrees |
| | $A_V = +2$ | +25°C | - | ± 0.05 | - | Degrees |
| 2nd Harmonic Distortion (30MHz, $V_{OUT} = 2V_{P.P.}$, Notes 1, 2) | $A_V = -1$ | +25°C | - | -52 | - | dBc |
| | $A_V = +1$ | +25°C | - | -57 | - | dBc |
| | $A_V = +2$ | +25°C | - | -52 | -45 | dBc |
| 3rd Harmonic Distortion (30MHz, $V_{OUT} = 2V_{P.P.}$, Notes 1, 2) | $A_V = -1$ | +25°C | - | -71 | - | dBc |
| | $A_V = +1$ | +25°C | - | -73 | - | dBc |
| | $A_V = +2$ | +25°C | - | -72 | -65 | dBc |
| 2nd Harmonic Distortion (50MHz, $V_{OUT} = 2V_{P.P.}$, Notes 1, 2) | $A_V = -1$ | +25°C | - | -47 | - | dBc |
| | $A_V = +1$ | +25°C | - | -53 | - | dBc |
| | $A_V = +2$ | +25°C | - | -47 | -40 | dBc |
| 3rd Harmonic Distortion (50MHz, $V_{OUT} = 2V_{P.P.}$, Notes 1, 2) | $A_V = -1$ | +25°C | - | -63 | - | dBc |
| | $A_V = +1$ | +25°C | - | -68 | - | dBc |
| | $A_V = +2$ | +25°C | - | -65 | -55 | dBc |
| 2nd Harmonic Distortion (100MHz, $V_{OUT} = 2V_{P.P.}$, Notes 1, 2) | $A_V = -1$ | +25°C | - | -41 | - | dBc |
| | $A_V = +1$ | +25°C | - | -50 | - | dBc |
| | $A_V = +2$ | +25°C | - | -42 | -35 | dBc |
| 3rd Harmonic Distortion (100MHz, $V_{OUT} = 2V_{P.P.}$, Notes 1, 2) | $A_V = -1$ | +25°C | - | -55 | - | dBc |
| | $A_V = +1$ | +25°C | - | -49 | - | dBc |
| | $A_V = +2$ | +25°C | - | -62 | -45 | dBc |

Specifications HFA1112

Electrical Specifications $V_{SUPPLY} = \pm 5V$, $A_V = +1$, $R_L = 100\Omega$, Unless Otherwise Specified (Continued)

| PARAMETER | TEMPERATURE | HFA1112I | | | UNITS | |
|---|--|----------|-----|------|-------|---------|
| | | MIN | TYP | MAX | | |
| 3rd Order Intercept ($A_V = +2$, Note 2) | 100MHz | +25°C | - | 28 | - | dBm |
| | 300MHz | +25°C | - | 13 | - | dBm |
| 1dB Compression ($A_V = +2$, Note 2) | 100MHz | +25°C | - | 19 | - | dBm |
| | 300MHz | +25°C | - | 12 | - | dBm |
| Reverse Isolation (S_{12} , Note 2) | 40MHz | +25°C | - | -70 | - | dB |
| | 100MHz | +25°C | - | -60 | - | dB |
| | 600MHz | +25°C | - | -32 | - | dB |
| TRANSIENT CHARACTERISTICS | | | | | | |
| Rise Time ($V_{OUT} = 0.5V$ Step, Note 1) | $A_V = -1$ | +25°C | - | 500 | 800 | ps |
| | $A_V = +1$ | +25°C | - | 480 | 750 | ps |
| | $A_V = +2$ | +25°C | - | 700 | 1000 | ps |
| Rise Time ($V_{OUT} = 2V$ Step) | $A_V = -1$ | +25°C | - | 0.82 | - | ns |
| | $A_V = +1$ | +25°C | - | 1.06 | - | ns |
| | $A_V = +2$ | +25°C | - | 1.00 | - | ns |
| Overshoot ($V_{OUT} = 0.5V$ Step, Input $t_R/t_F = 200ps$, Notes 1, 2, 3) | $A_V = -1$ | +25°C | - | 12 | 30 | % |
| | $A_V = +1$ | +25°C | - | 45 | 65 | % |
| | $A_V = +2$ | +25°C | - | 6 | 20 | % |
| 0.1% Settling ($V_{OUT} = 2V$ to $0V$, Note 2) | | +25°C | - | 11 | - | ns |
| 0.05% Settling ($V_{OUT} = 2V$ to $0V$) | | +25°C | - | 15 | - | ns |
| Overdrive Recovery Time ($V_{IN} = 5V_{P-P}$) | | +25°C | - | 8.5 | - | ns |
| Differential Gain | $A_V = +1$, 3.58MHz, $R_L = 150\Omega$ | +25°C | - | 0.03 | - | % |
| | $A_V = +2$, 3.58MHz, $R_L = 150\Omega$ | +25°C | - | 0.02 | - | % |
| Differential Phase | $A_V = +1$, 3.58MHz, $R_L = 150\Omega$ | +25°C | - | 0.05 | - | Degrees |
| | $A_V = +2$, 3.58MHz, $R_L = 150\Omega$ | +25°C | - | 0.04 | - | Degrees |

NOTES:

1. This parameter is not tested. The limits are guaranteed based on lab characterization, and reflect lot-to-lot variation.
2. See Typical Performance Curves for more information.
3. Overshoot decreases as input transition times increase, especially for $A_V = +1$. Please refer to Performance Curves.

HFA1112

Die Characteristics

DIE DIMENSIONS:

63 x 44 x 19 ± 1 mils
1600µm x 1130µm ± 25.4µm

METALLIZATION:

Type: Metal 1: AlCu (2%)/TiW Type: Metal 2: AlCu (2%)
Thickness: Metal 1: 8kÅ ± 0.4kÅ Thickness: Metal 2: 16kÅ ± 0.8kÅ

GLASSIVATION:

Type: Nitride
Thickness: 4kÅ ± 0.5kÅ

DIE ATTACH:

Material: Epoxy - Plastic DIP and SOIC

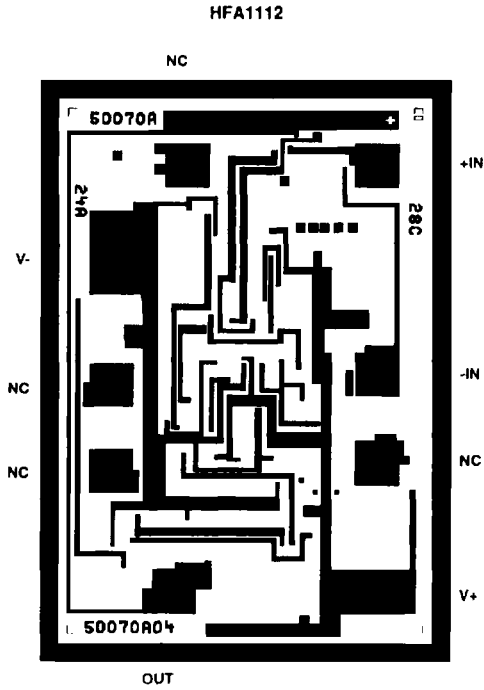
WORST CASE CURRENT DENSITY:

2.12 x 10⁵ A/cm² at 50mA

TRANSISTOR COUNT: 52

SUBSTRATE POTENTIAL (Powered Up): Floating (Recommend Connection to V-)

Metallization Mask Layout



Application Information

Closed Loop Gain Selection

The HFA1112 features a novel design which allows the user to select from three closed loop gains, without any external components. The result is a more flexible product, fewer part types in inventory, and more efficient use of board space.

This "buffer" operates in closed loop gains of -1, +1, or +2, and gain selection is accomplished via connections to the \pm inputs. Applying the input signal to +IN and floating -IN selects a gain of +1, while grounding -IN selects a gain of +2. A gain of -1 is obtained by applying the input signal to -IN with +IN grounded.

The table below summarizes these connections:

| GAIN (A_{CL}) | CONNECTIONS | |
|----------------------|----------------|----------------|
| | +INPUT (PIN 3) | -INPUT (PIN 2) |
| -1 | GND | Input |
| +1 | Input | NC (Floating) |
| +2 | Input | GND |

PC Board Layout

The frequency response of this amplifier depends greatly on the amount of care taken in designing the PC board. **The use of low inductance components such as chip resistors and chip capacitors is strongly recommended, while a solid ground plane is a must!**

Attention should be given to decoupling the power supplies. A large value (10 μ F) tantalum in parallel with a small value (0.1 μ F) chip capacitor works well in most cases.

Terminated microstrip signal lines are recommended at the input and output of the device. Capacitance directly on the output must be minimized, or isolated as discussed in the next section.

For unity gain applications, care must also be taken to minimize the capacitance to ground seen by the amplifier's inverting input. At higher frequencies this capacitance will tend to short the -INPUT to GND, resulting in a closed loop gain which increases with frequency. This will cause excessive high frequency peaking and potentially other problems as well.

An example of a good high frequency layout is the Evaluation Board shown in Figure 2.

Driving Capacitive Loads

Capacitive loads, such as an A/D input, or an improperly terminated transmission line will degrade the amplifier's

phase margin resulting in frequency response peaking and possible oscillations. In most cases, the oscillation can be avoided by placing a resistor (R_S) in series with the output prior to the capacitance.

Figure 1 details starting points for the selection of this resistor. The points on the curve indicate the R_S and C_L combinations for the optimum bandwidth, stability, and settling time, but experimental fine tuning is recommended. Picking a point above or to the right of the curve yields an overdamped response, while points below or left of the curve indicate areas of underdamped performance.

R_S and C_L form a low pass network at the output, thus limiting system bandwidth well below the amplifier bandwidth of 850MHz. By decreasing R_S as C_L increases (as illustrated in the curves), the maximum bandwidth is obtained without sacrificing stability. Even so, bandwidth does decrease as you move to the right along the curve. For example, at $A_V = +1$, $R_S = 50\Omega$, $C_L = 30pF$, the overall bandwidth is limited to 300MHz, and bandwidth drops to 100MHz at $A_V = +1$, $R_S = 5\Omega$, $C_L = 340pF$.

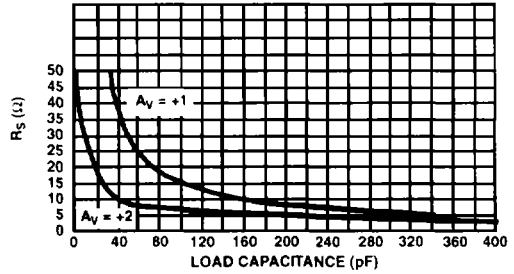


FIGURE 1. RECOMMENDED SERIES OUTPUT RESISTOR vs LOAD CAPACITANCE

Evaluation Board

The performance of the HFA1112 may be evaluated using the HFA11XX Evaluation Board, slightly modified as follows:

1. Remove the 500 Ω feedback resistor (R_2), and leave the connection open.
2. a. For $A_V = +1$ evaluation, remove the 500 Ω gain setting resistor (R_1), and leave pin 2 floating.
b. For $A_V = +2$, replace the 500 Ω gain setting resistor with a 0 Ω resistor to GND.

The layout and modified schematic of the board are shown in Figure 2.

To order evaluation boards, please contact your local sales office.

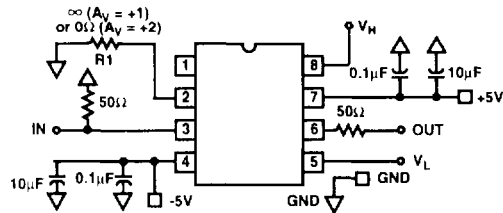
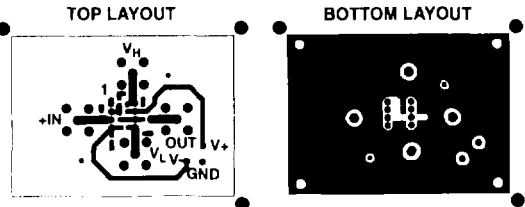


FIGURE 2. EVALUATION BOARD SCHEMATIC AND LAYOUT



Typical Performance Curves $V_{SUPPLY} = \pm 15V$, $T_A = +25^\circ C$, $R_L = 100\Omega$, Unless Otherwise Specified

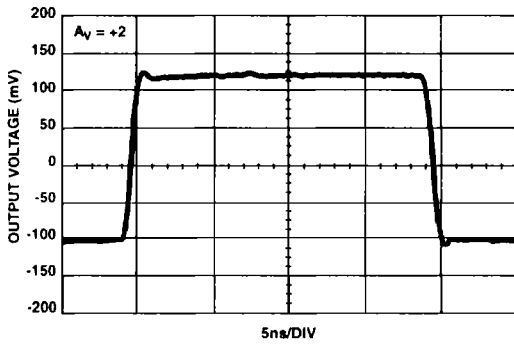


FIGURE 3. SMALL SIGNAL PULSE RESPONSE

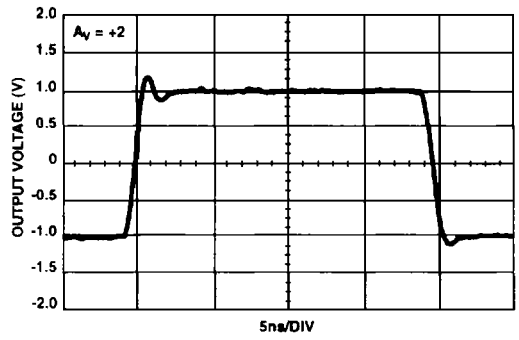


FIGURE 4. LARGE SIGNAL PULSE RESPONSE

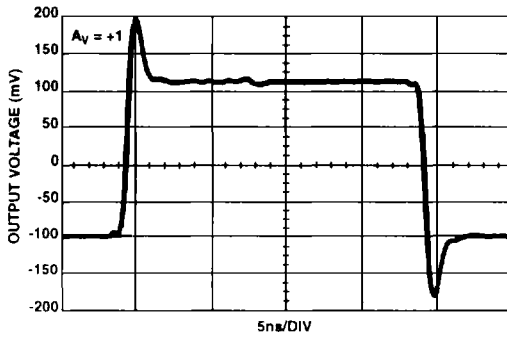


FIGURE 5. SMALL SIGNAL PULSE RESPONSE

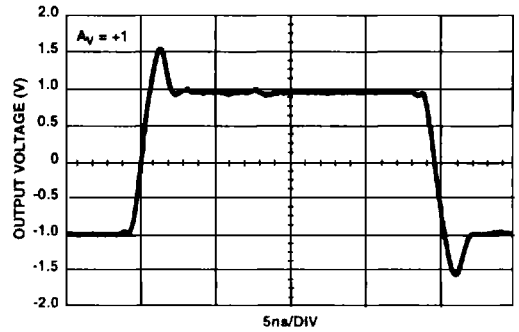


FIGURE 6. LARGE SIGNAL PULSE RESPONSE

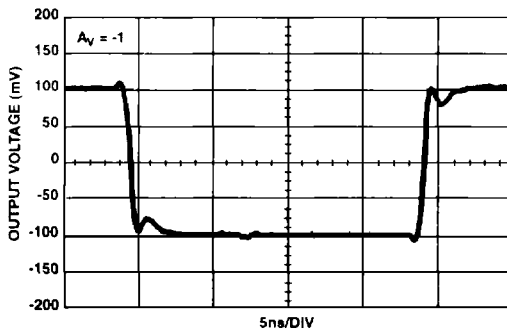


FIGURE 7. SMALL SIGNAL PULSE RESPONSE

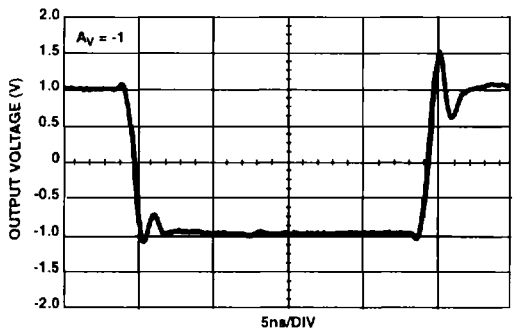


FIGURE 8. LARGE SIGNAL PULSE RESPONSE

Typical Performance Curves $V_{SUPPLY} = \pm 5V$, $T_A = +25^\circ C$, $R_L = 100\Omega$, Unless Otherwise Specified (Continued)

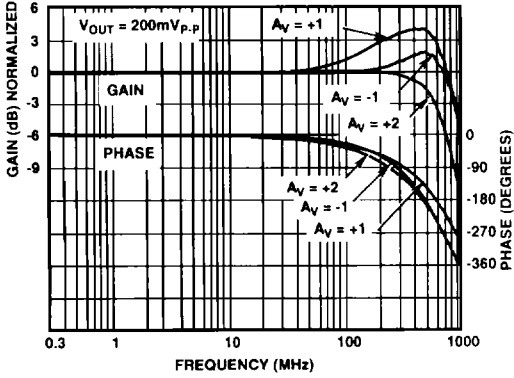


FIGURE 9. FREQUENCY RESPONSE

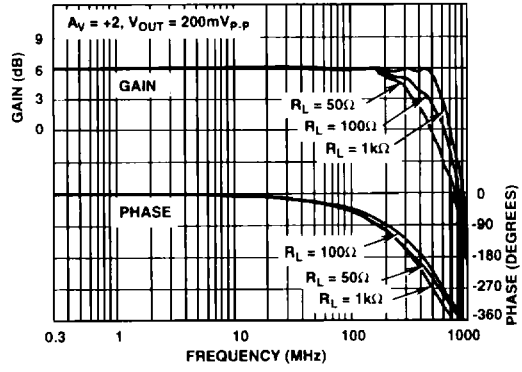


FIGURE 10. FREQUENCY RESPONSE FOR VARIOUS LOAD RESISTORS

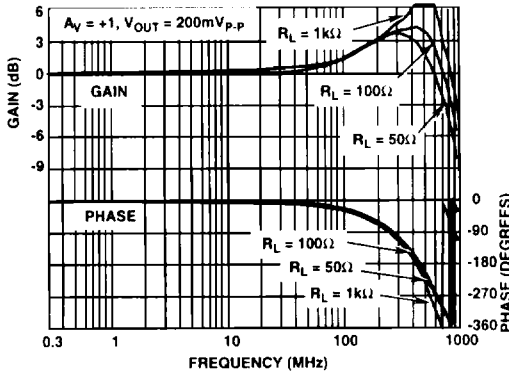


FIGURE 11. FREQUENCY RESPONSE FOR VARIOUS LOAD RESISTORS

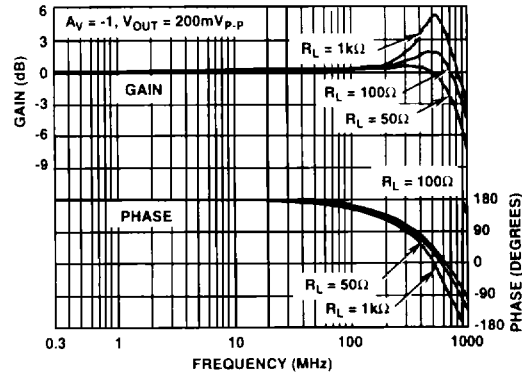


FIGURE 12. FREQUENCY RESPONSE FOR VARIOUS LOAD RESISTORS

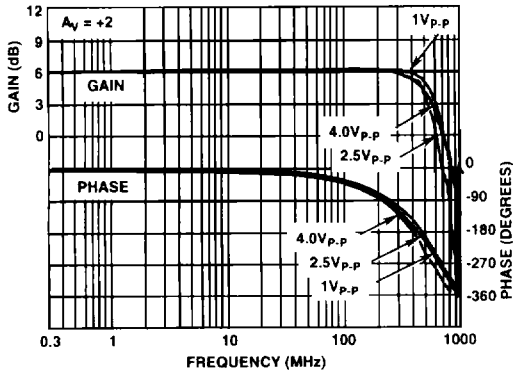


FIGURE 13. FREQUENCY RESPONSE FOR VARIOUS OUTPUT VOLTAGES

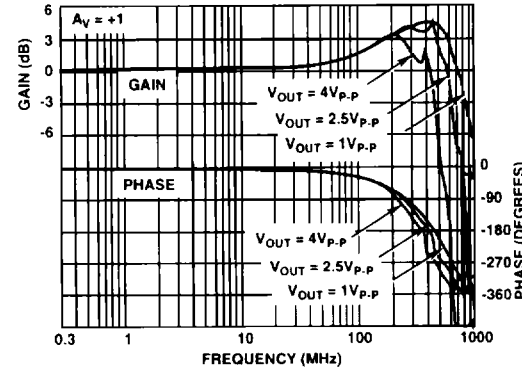


FIGURE 14. FREQUENCY RESPONSE FOR VARIOUS OUTPUT VOLTAGES

Typical Performance Curves $V_{SUPPLY} = \pm 5V$, $T_A = +25^\circ C$, $R_L = 100\Omega$, Unless Otherwise Specified (Continued)

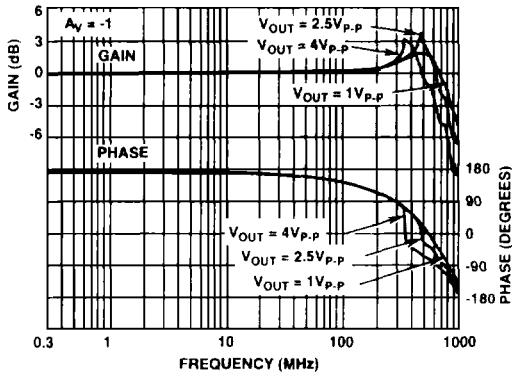


FIGURE 15. FREQUENCY RESPONSE FOR VARIOUS OUTPUT VOLTAGES

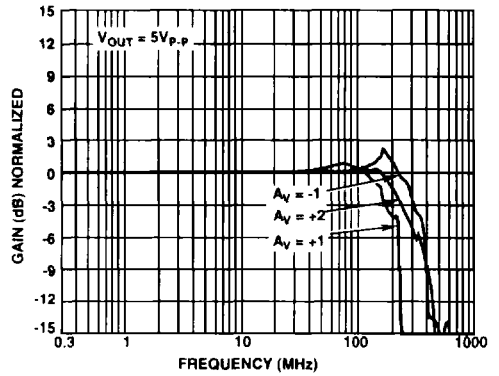


FIGURE 16. FULL POWER BANDWIDTH

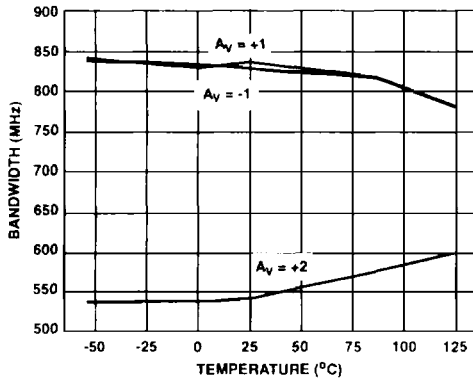


FIGURE 17. -3dB BANDWIDTH vs TEMPERATURE

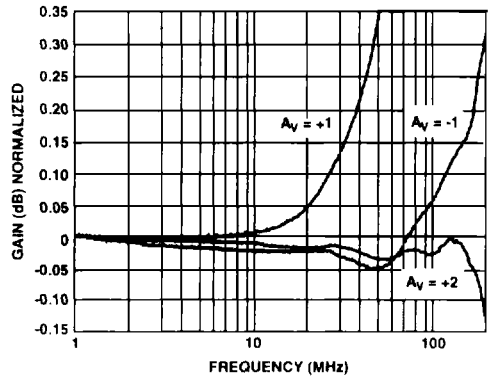


FIGURE 18. GAIN FLATNESS

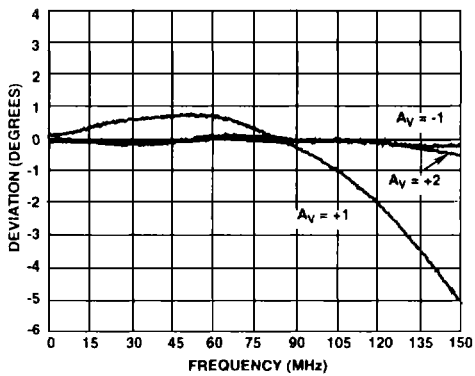


FIGURE 19. DEVIATION FROM LINEAR PHASE

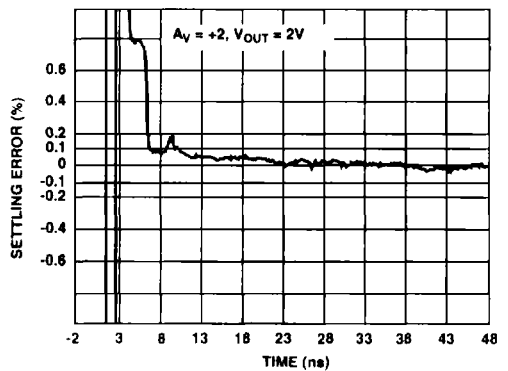


FIGURE 20. SETTLING RESPONSE

Typical Performance Curves $V_{SUPPLY} = \pm 15V$, $T_A = +25^\circ C$, $R_L = 100\Omega$, Unless Otherwise Specified (Continued)

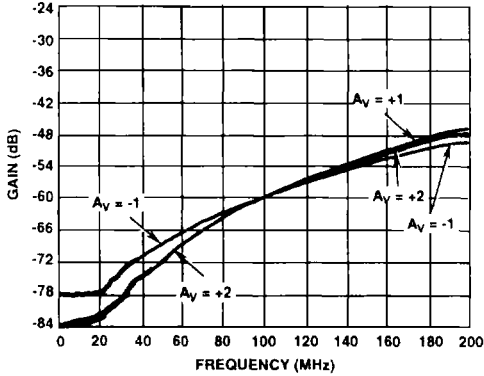


FIGURE 21. LOW FREQUENCY REVERSE ISOLATION (S_{12})

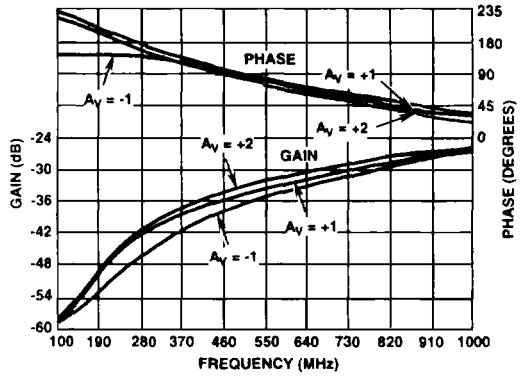


FIGURE 22. HIGH FREQUENCY REVERSE ISOLATION (S_{12})

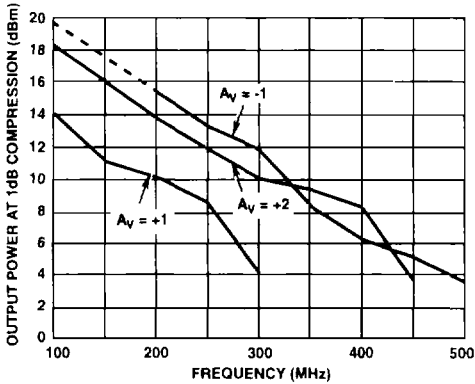


FIGURE 23. 1dB GAIN COMPRESSION vs FREQUENCY

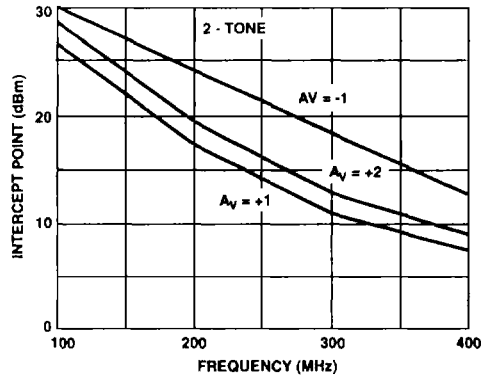


FIGURE 24. 3rd ORDER INTERMODULATION INTERCEPT vs FREQUENCY

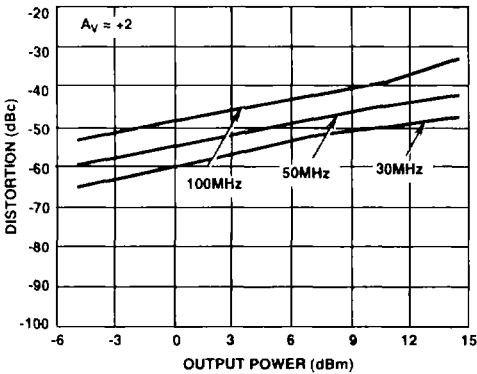


FIGURE 25. 2nd HARMONIC DISTORTION vs P_{OUT}

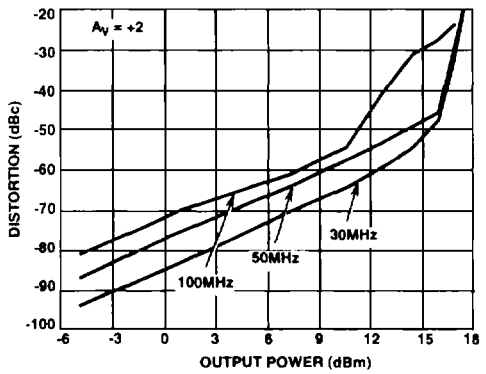


FIGURE 26. 3rd HARMONIC DISTORTION vs P_{OUT}

Typical Performance Curves $V_{SUPPLY} = \pm 5V$, $T_A = +25^\circ C$, $R_L = 100\Omega$, Unless Otherwise Specified (Continued)

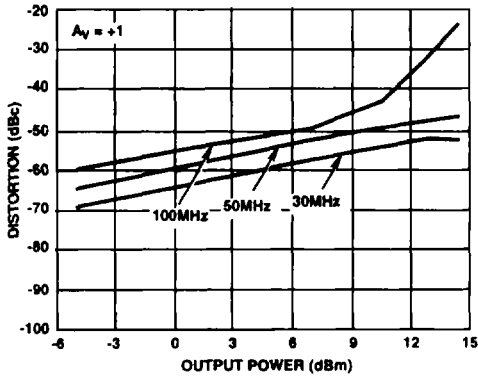


FIGURE 27. 2nd HARMONIC DISTORTION vs P_{OUT}

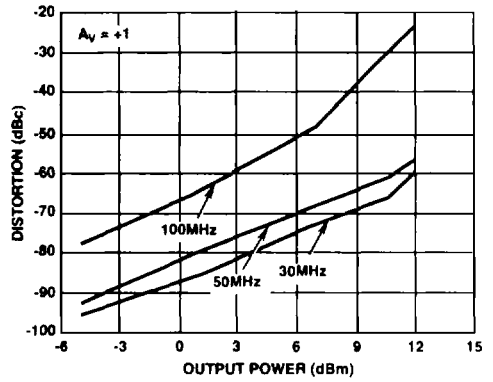


FIGURE 28. 3rd HARMONIC DISTORTION vs P_{OUT}

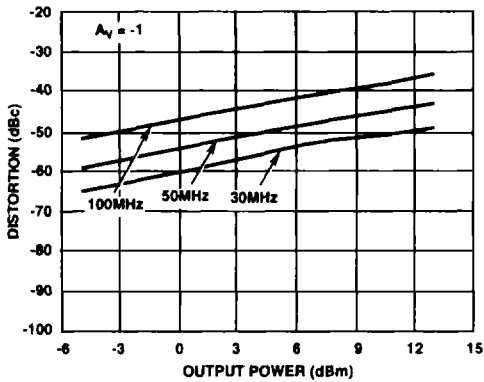


FIGURE 29. 2nd HARMONIC DISTORTION vs P_{OUT}

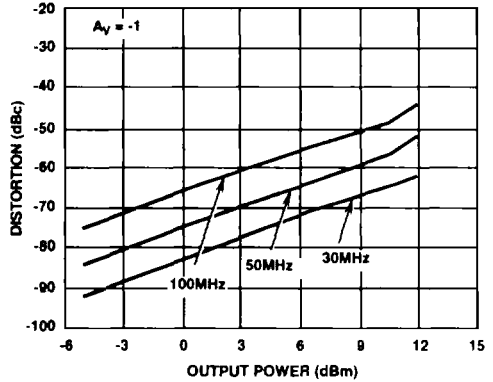


FIGURE 30. 3rd HARMONIC DISTORTION vs P_{OUT}

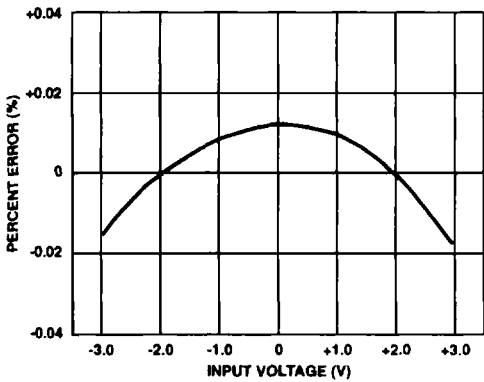


FIGURE 31. INTEGRAL LINEARITY ERROR

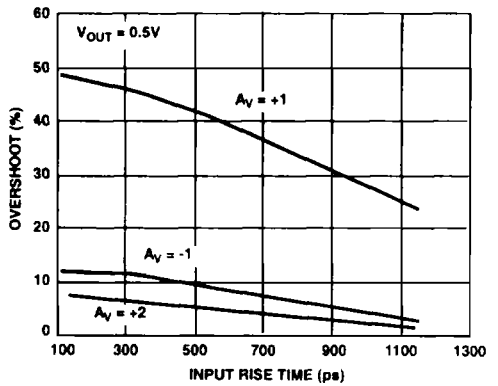


FIGURE 32. OVERSHOOT vs INPUT RISE TIME

Typical Performance Curves $V_{SUPPLY} = \pm 5V$, $T_A = +25^\circ C$, $R_L = 100\Omega$, Unless Otherwise Specified (Continued)

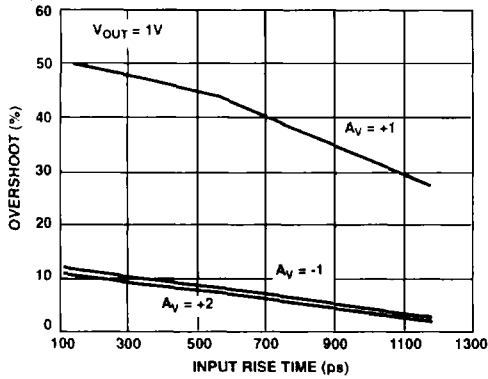


FIGURE 33. OVERSHOOT vs INPUT RISE TIME

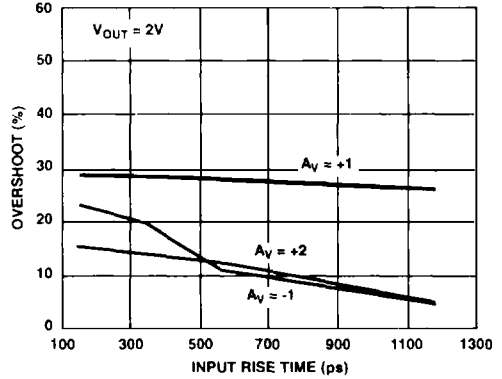


FIGURE 34. OVERSHOOT vs INPUT RISE TIME

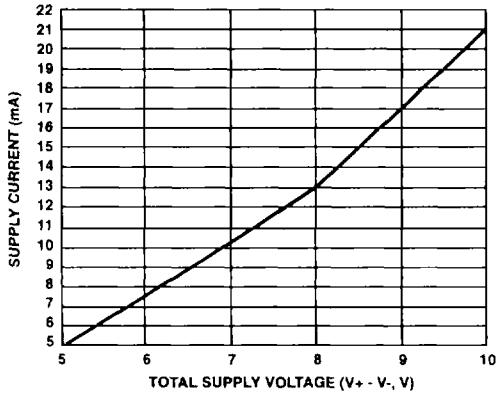


FIGURE 35. SUPPLY CURRENT vs SUPPLY VOLTAGE

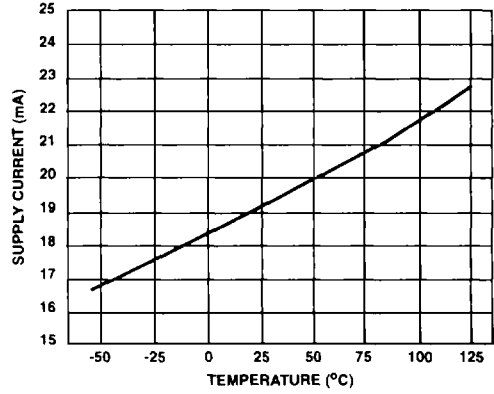


FIGURE 36. SUPPLY CURRENT vs TEMPERATURE

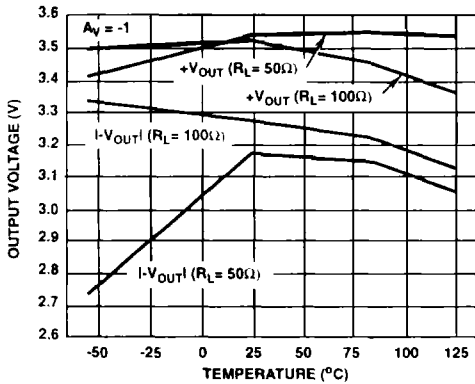


FIGURE 37. OUTPUT VOLTAGE vs TEMPERATURE

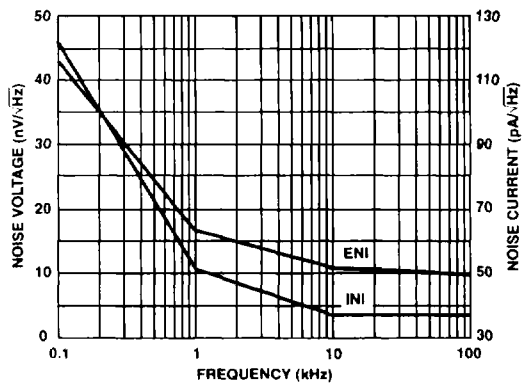


FIGURE 38. INPUT NOISE CHARACTERISTICS