September 1998 File Number 2992.5

850MHz, Low Distortion Programmable Gain Buffer Amplifier

The HFA1112 is a closed loop Buffer featuring user programmable gain and ultra high speed performance. Manufactured on Intersil's 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.

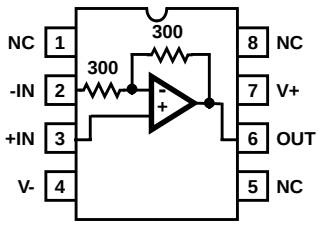
A unique feature of the pinout allows the user to select a voltage gain of +1, -1, or +2, without the use of any external components. Gain selection is accomplished via connections to the inputs, as described in the "Application Information" section. The result is a more flexible product, fewer part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

Pinout

HFA1112
(PDIP, SOIC)
TOP VIEW



Pin Description

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

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/µs
- 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
- Related Literature
  - AN9507, Video Cable Drivers Save Board Space

Ordering Information

PART NUMBER (BRAND)	TEMP. RANGE (^{o}C)	PACKAGE	PKG. NO.
HFA1112IP	-40 to 85	8 Ld PDIP	E8.3
HFA1112IB (H1112I)	-40 to 85	8 Ld SOIC	M8.15
HFA11XXEVAL	High Speed Op Amp DIP Evaluation Board		

Absolute Maximum Ratings

Voltage Between V+ and V- 12V
Input Voltage . . . . . V_{SUPPLY}
Output Current 60mA

Operating Conditions

Temperature Range . . . . . -40^oC to 85^oC

Thermal Information

Thermal Resistance (Typical, Note 1)	θ_{JA} ($^oC/W$)	θ_{JC} ($^oC/W$)
PDIP Package	98	N/A
SOIC Package	170	N/A

Maximum Junction Temperature (Plastic Package) . . . . . 150^oC
Maximum Storage Temperature Range . . . . . -65^oC to 150^oC
Maximum Lead Temperature (Soldering 10s) . . . . . 300^oC
(SOIC - Lead Tips Only)

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.

NOTE:

1. θ_{JA} is measured with the component mounted on an evaluation PC board in free air.

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

PARAMETER	TEST CONDITIONS	TEMP (^oC)	MIN	TYP	MAX	UNITS
INPUT CHARACTERISTICS						
Output Offset Voltage		25	-	8	25	mV
		Full	-	-	35	mV
Output Offset Voltage Drift		Full	-	10	-	$\mu V/^oC$
PSRR		25	39	45	-	dB
		Full	35	-	-	dB
Input Noise Voltage (Note 3)	100kHz	25	-	9	-	$nV/\sqrt{Hz}$
Non-Inverting Input Noise Current (Note 3)	100kHz	25	-	37	-	$pA/\sqrt{Hz}$
Non-Inverting Input Bias Current		25	-	25	40	µA
		Full	-	-	65	µA
Non-Inverting Input Resistance		25	25	50	-	kΩ
Inverting Input Resistance (Note 2)		25	240	300	360	Ω
Input Capacitance		25	-	2	-	pF
Input Common Mode Range		Full	±2.5	±2.8	-	V
TRANSFER CHARACTERISTICS						
Gain	A_V = +1, V_{IN} = +2V	25	0.980	0.990	1.02	V/V
		Full	0.975	-	1.025	V/V
Gain	A_V = +2, V_{IN} = +1V	25	1.96	1.98	2.04	V/V
		Full	1.95	-	2.05	V/V
DC Non-Linearity (Note 3)	A_V = +2, ±2V Full Scale	25	-	0.02	-	%
OUTPUT CHARACTERISTICS						
Output Voltage (Note 3)	A_V = -1	25	±3.0	±3.3	-	V
		Full	±2.5	±3.0	-	V
Output Current (Note 3)	R_L = 50Ω	25, 85	50	60	-	mA
		-40	35	50	-	mA
Closed Loop Output Impedance	DC, A_V = +2	25	-	0.3	-	Ω
POWER SUPPLY CHARACTERISTICS						
Supply Voltage Range		Full	±4.5	-	±5.5	V
Supply Current (Note 3)		25	-	21	26	mA
		Full	-	-	33	mA

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

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

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

PARAMETER	TEST CONDITIONS	TEMP (°C)	MIN	TYP	MAX	UNITS
3rd Order Intercept (A_V = +2, Note 3)	100MHz	25	-	28	-	dBm
	300MHz	25	-	13	-	dBm
1dB Compression (A_V = +2, Note 3)	100MHz	25	-	19	-	dBm
	300MHz	25	-	12	-	dBm
Reverse Isolation (S_{12}, Note 3)	40MHz	25	-	-70	-	dB
	100MHz	25	-	-60	-	dB
	600MHz	25	-	-32	-	dB
TRANSIENT CHARACTERISTICS						
Rise Time (V_{OUT} = 0.5V Step, Note 2)	A_V = -1	25	-	500	800	ps
	A_V = +1	25	-	480	750	ps
	A_V = +2	25	-	700	1000	ps
Rise Time (V_{OUT} = 2V Step)	A_V = -1	25	-	0.82	-	ns
	A_V = +1	25	-	1.06	-	ns
	A_V = +2	25	-	1.00	-	ns
Overshoot (V_{OUT} = 0.5V Step, Input t_R/t_F = 200ps, Notes 2, 3, 4)	A_V = -1	25	-	12	30	%
	A_V = +1	25	-	45	65	%
	A_V = +2	25	-	6	20	%
0.1% Settling Time (Note 3)	V_{OUT} = 2V to 0V	25	-	11	-	ns
0.05% Settling Time	V_{OUT} = 2V to 0V	25	-	15	-	ns
Overdrive Recovery Time	V_{IN} = $5V_{P-P}$	25	-	8.5	-	ns
Differential Gain	A_V = +1, 3.58MHz, R_L = 150Ω	25	-	0.03	-	%
	A_V = +2, 3.58MHz, R_L = 150Ω	25	-	0.02	-	%
Differential Phase	A_V = +1, 3.58MHz, R_L = 150Ω	25	-	0.05	-	Degrees
	A_V = +2, 3.58MHz, R_L = 150Ω	25	-	0.04	-	Degrees

NOTES:

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

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 ±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 (10µF) tantalum in parallel with a small value (0.1µF) 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 = 50Ω, C_L = 30pF, the overall bandwidth is limited to 300MHz, and bandwidth drops to 100MHz at A_V = +1, R_S = 5Ω, C_L = 340pF.

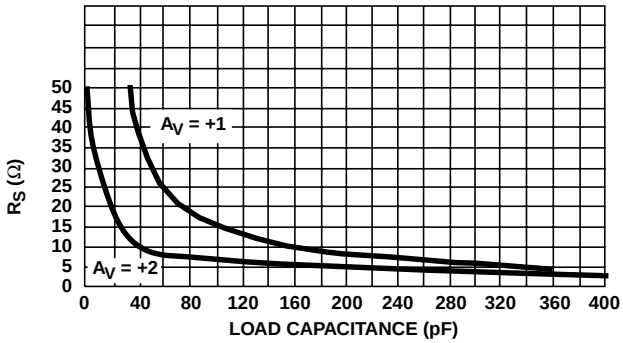


FIGURE 1. RECOMMENDED SERIES OUTPUT RESISTOR vs LOAD CAPACITANCE

Evaluation Board

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

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

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

To order evaluation boards (part number HFA11XXEVAL), please contact your local sales office.

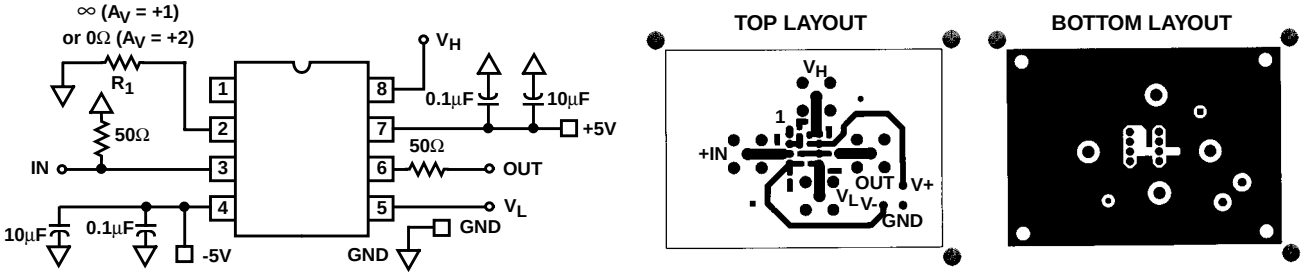


FIGURE 2. EVALUATION BOARD SCHEMATIC AND LAYOUT

Typical Performance Curves $V_{SUPPLY} = \pm5V$, $T_A = 25^oC$, $R_L = 100\Omega$, Unless Otherwise Specified

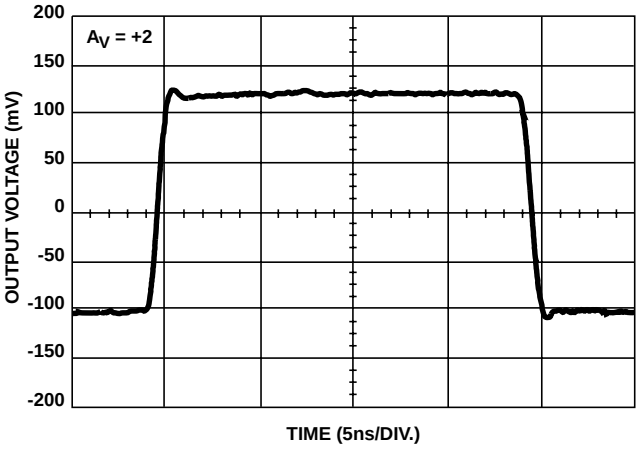


FIGURE 3. SMALL SIGNAL PULSE RESPONSE

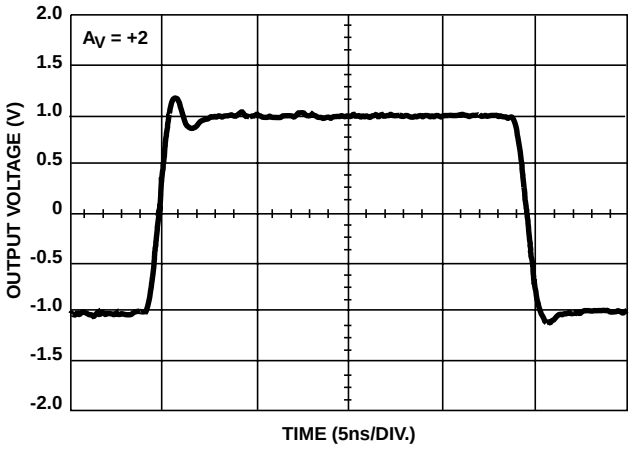


FIGURE 4. LARGE SIGNAL PULSE RESPONSE

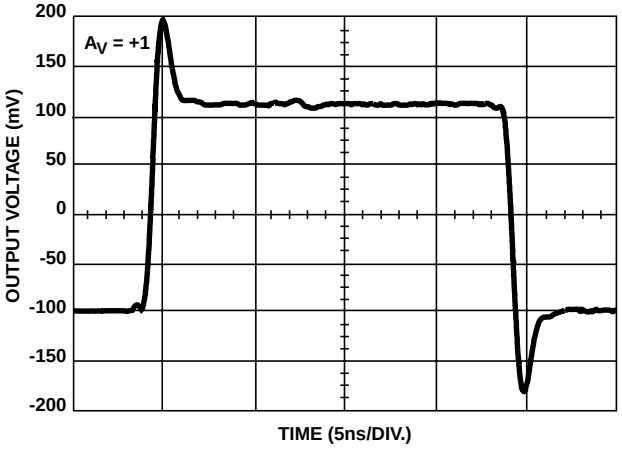


FIGURE 5. SMALL SIGNAL PULSE RESPONSE

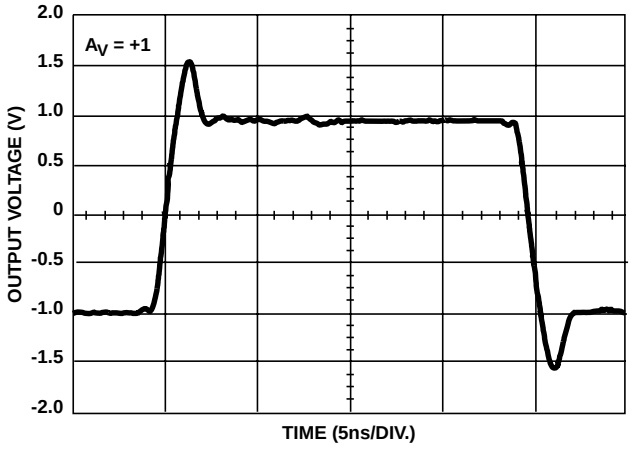


FIGURE 6. LARGE SIGNAL PULSE RESPONSE

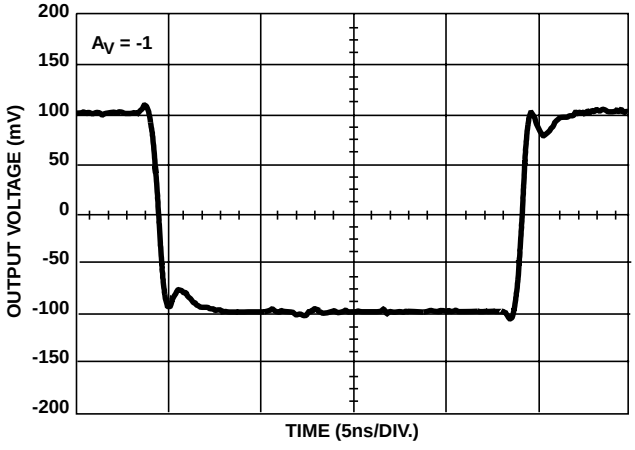


FIGURE 7. SMALL SIGNAL PULSE RESPONSE

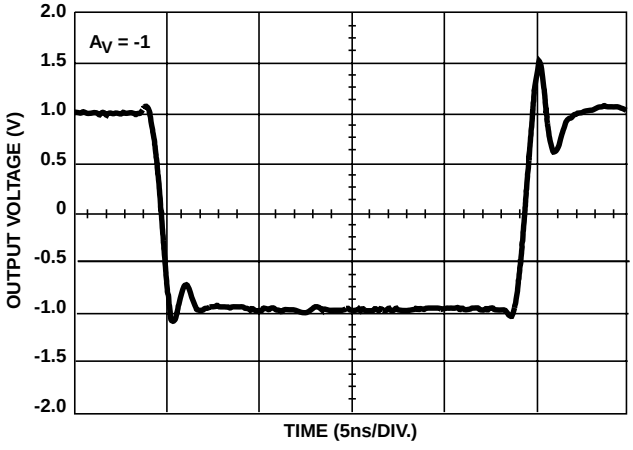


FIGURE 8. LARGE SIGNAL PULSE RESPONSE

Typical Performance Curves $V_{SUPPLY} = \pm5V$, $T_A = 25^oC$, $R_L = 100\Omega$, Unless Otherwise Specified **(Continued)**

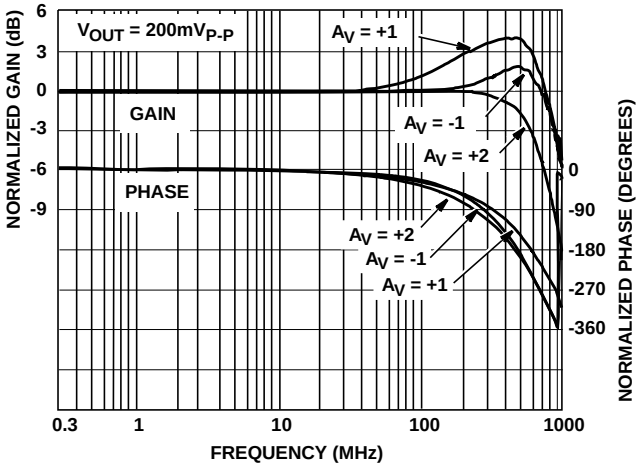


FIGURE 9. FREQUENCY RESPONSE

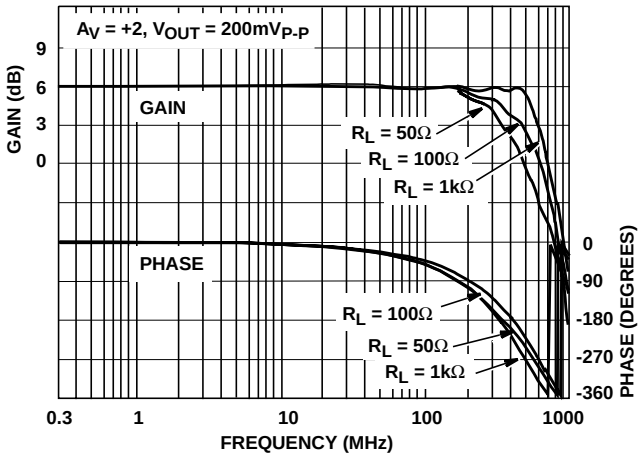


FIGURE 10. FREQUENCY RESPONSE FOR VARIOUS LOAD RESISTORS

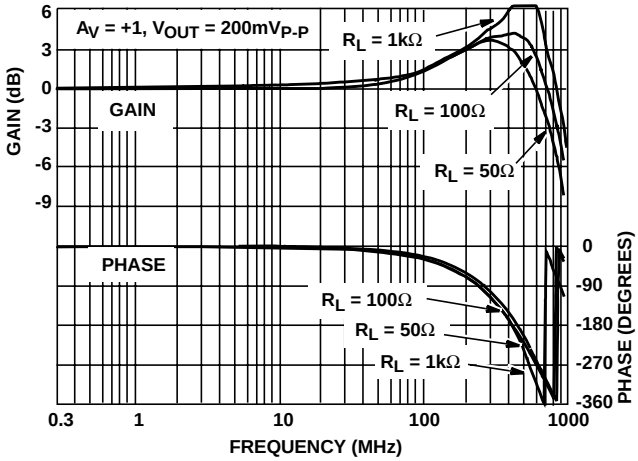


FIGURE 11. FREQUENCY RESPONSE FOR VARIOUS LOAD RESISTORS

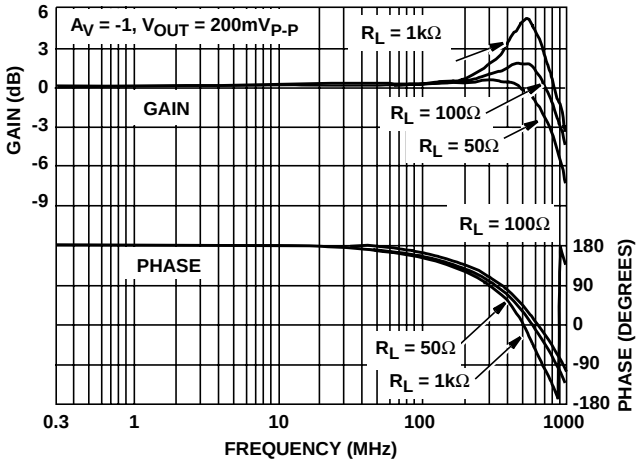


FIGURE 12. FREQUENCY RESPONSE FOR VARIOUS LOAD RESISTORS

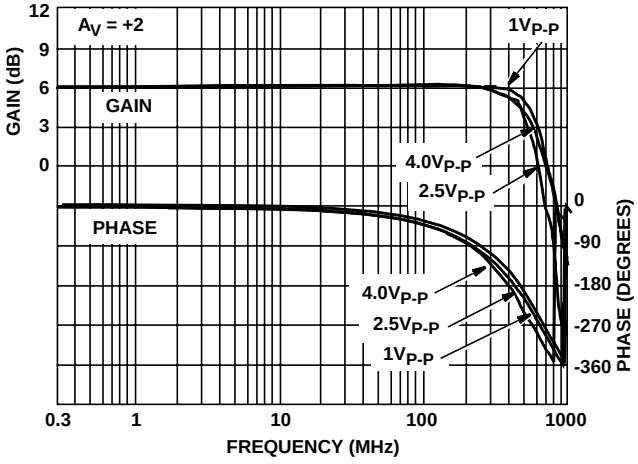


FIGURE 13. FREQUENCY RESPONSE FOR VARIOUS OUTPUT VOLTAGES

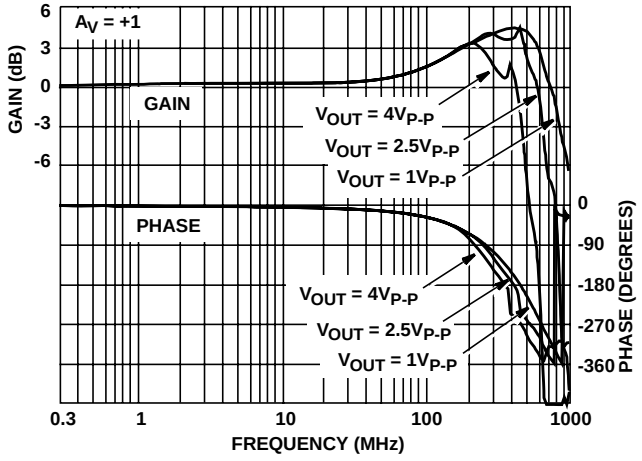


FIGURE 14. FREQUENCY RESPONSE FOR VARIOUS OUTPUT VOLTAGES

Typical Performance Curves $V_{SUPPLY} = \pm5V$, $T_A = 25^oC$, $R_L = 100\Omega$, Unless Otherwise Specified **(Continued)**

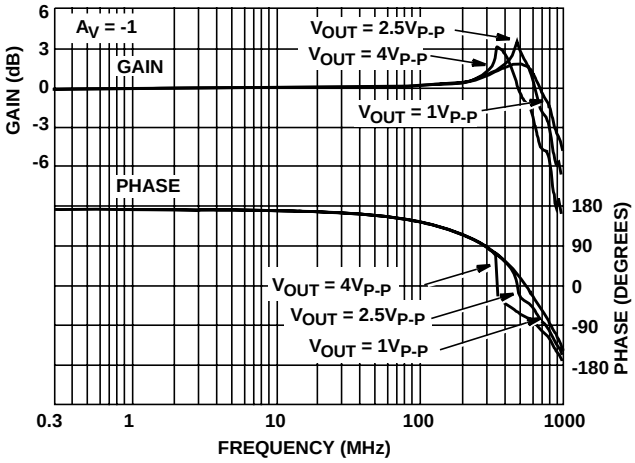


FIGURE 15. FREQUENCY RESPONSE FOR VARIOUS OUTPUT VOLTAGES

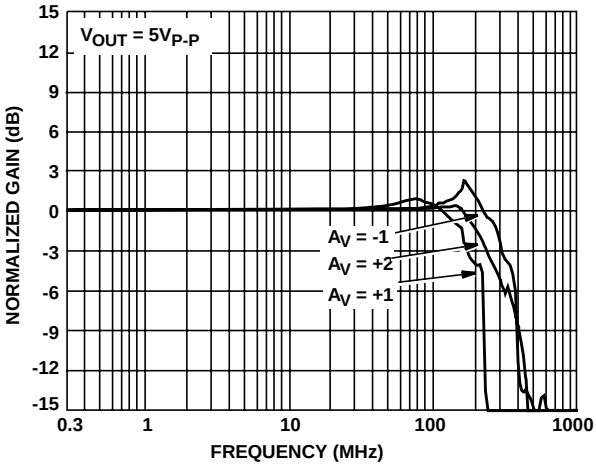


FIGURE 16. FULL POWER BANDWIDTH

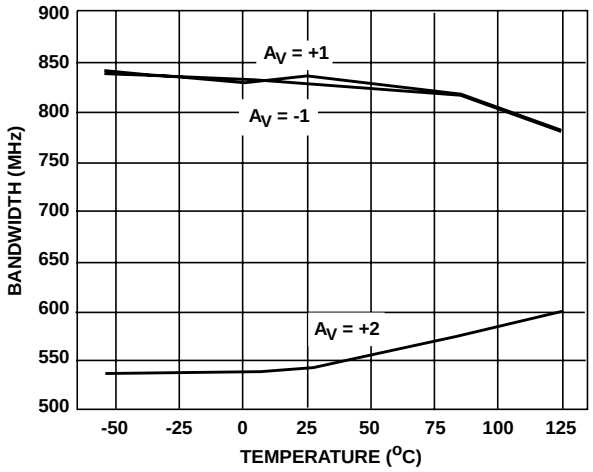


FIGURE 17. -3dB BANDWIDTH vs TEMPERATURE

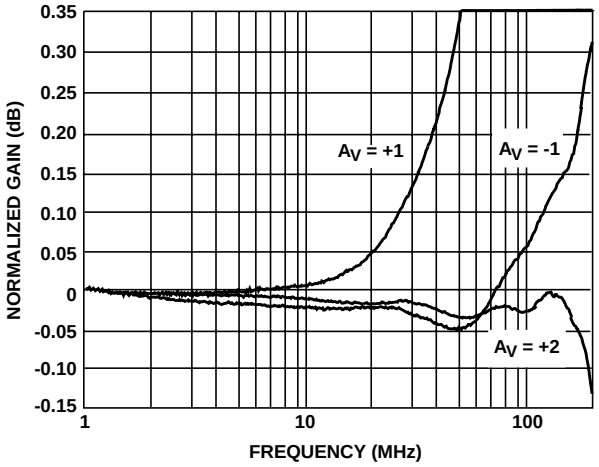


FIGURE 18. GAIN FLATNESS

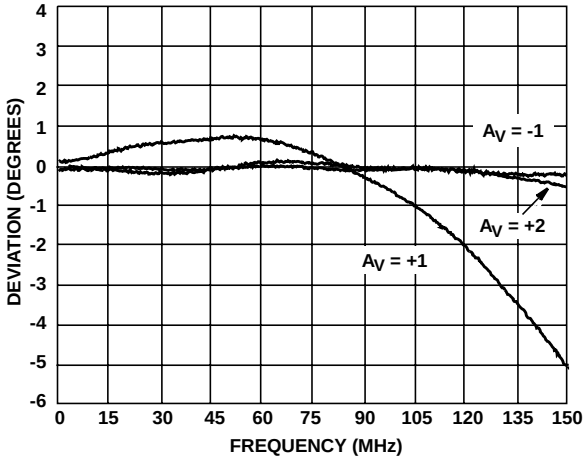


FIGURE 19. DEVIATION FROM LINEAR PHASE

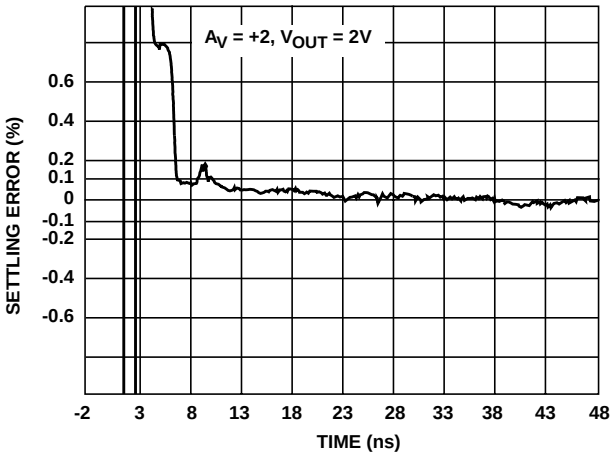


FIGURE 20. SETTLING RESPONSE

Typical Performance Curves $V_{SUPPLY} = \pm5V$, $T_A = 25^oC$, $R_L = 100\Omega$, Unless Otherwise Specified **(Continued)**

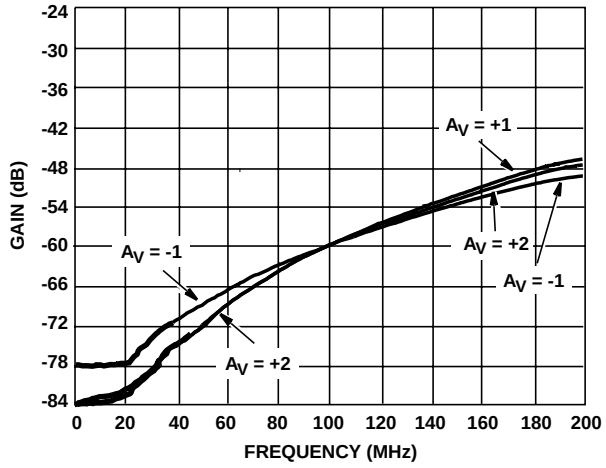


FIGURE 21. LOW FREQUENCY REVERSE ISOLATION (S_{12})

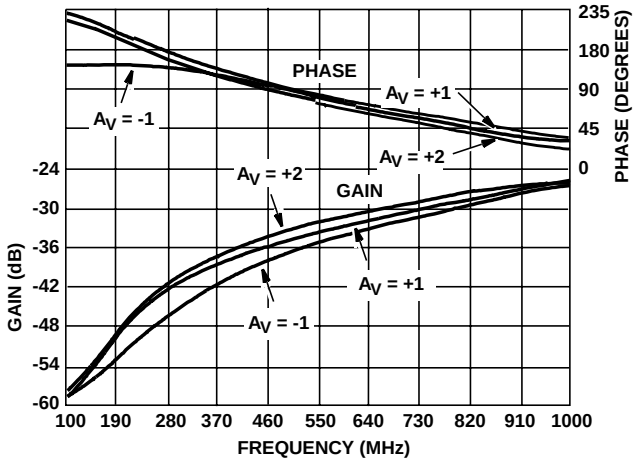


FIGURE 22. HIGH FREQUENCY REVERSE ISOLATION (S_{12})

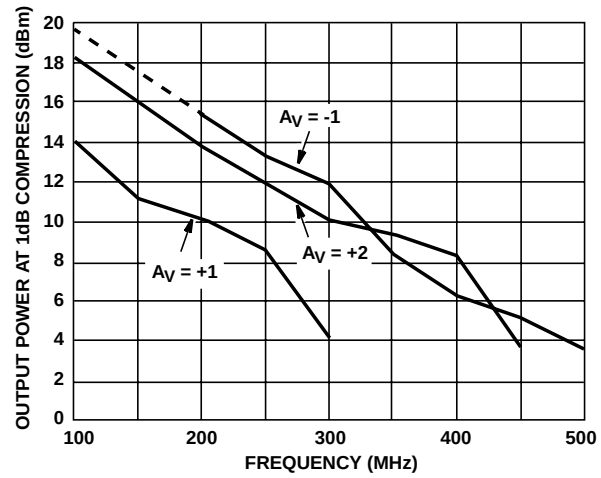


FIGURE 23. 1dB GAIN COMPRESSION vs FREQUENCY

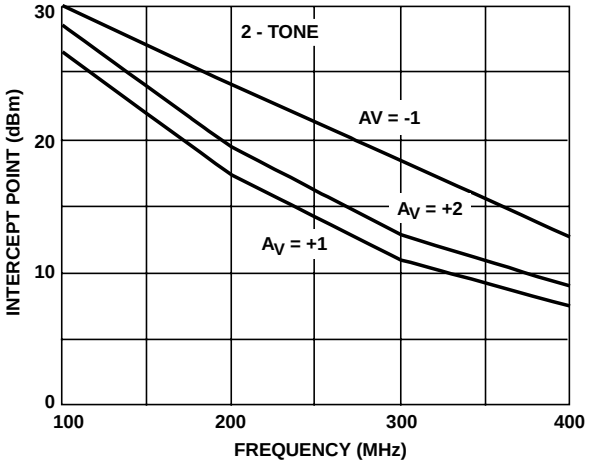


FIGURE 24. 3rd ORDER INTERMODULATION INTERCEPT vs FREQUENCY

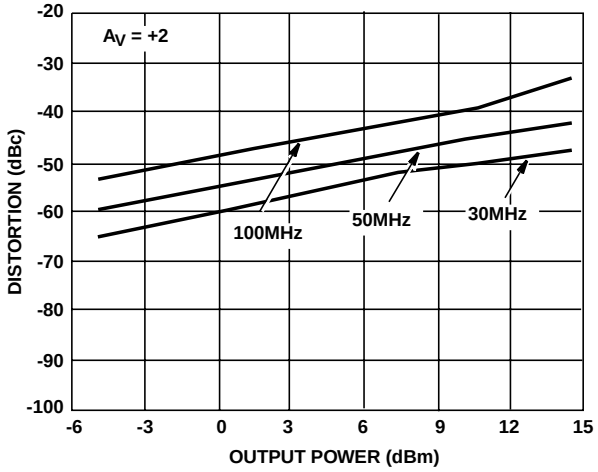


FIGURE 25. 2nd HARMONIC DISTORTION vs P_{OUT}

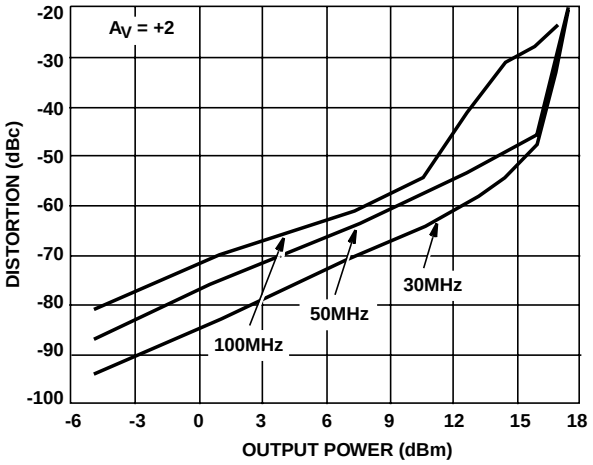


FIGURE 26. 3rd HARMONIC DISTORTION vs P_{OUT}

Typical Performance Curves $V_{SUPPLY} = \pm5V$, $T_A = 25^oC$, $R_L = 100\Omega$, Unless Otherwise Specified **(Continued)**

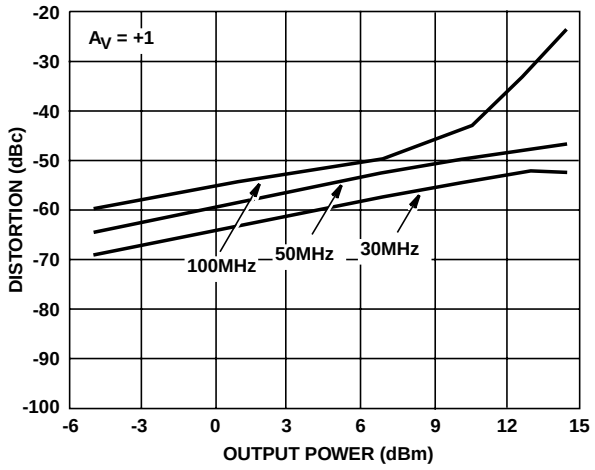


FIGURE 27. 2nd HARMONIC DISTORTION vs P_{OUT}

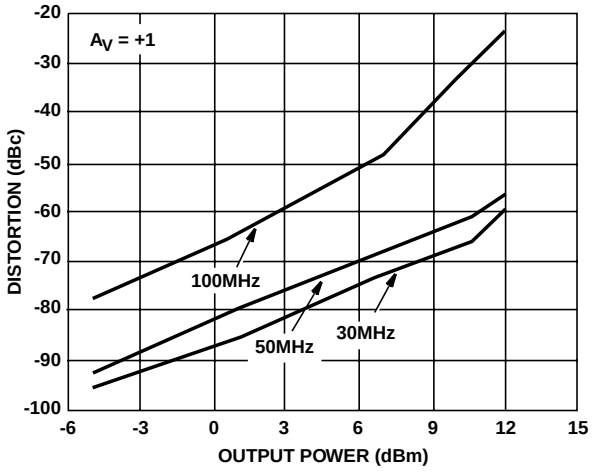


FIGURE 28. 3rd HARMONIC DISTORTION vs P_{OUT}

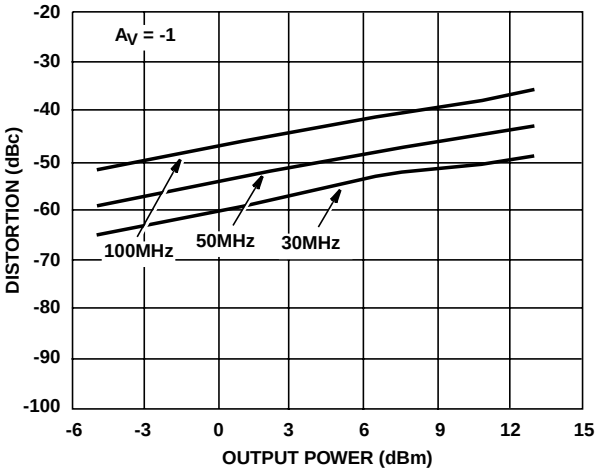


FIGURE 29. 2nd HARMONIC DISTORTION vs P_{OUT}

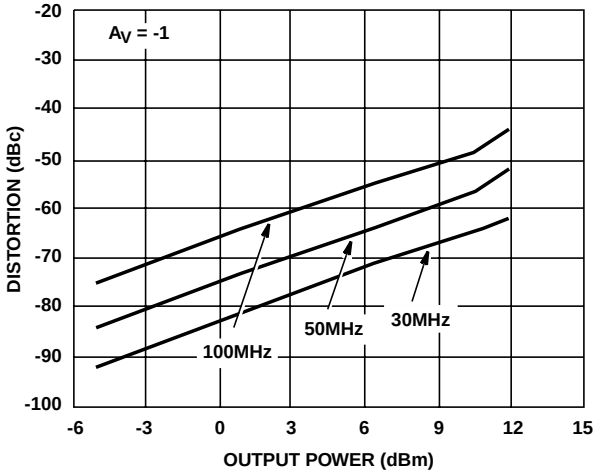


FIGURE 30. 3rd HARMONIC DISTORTION vs P_{OUT}

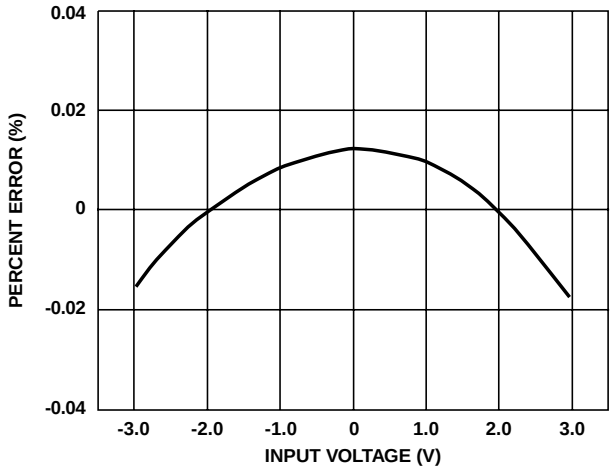


FIGURE 31. INTEGRAL LINEARITY ERROR

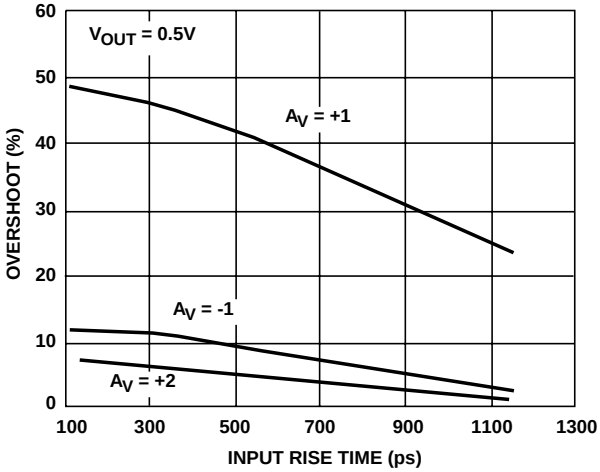


FIGURE 32. OVERSHOOT vs INPUT RISE TIME

Typical Performance Curves $V_{SUPPLY} = \pm5V$, $T_A = 25^oC$, $R_L = 100\Omega$, Unless Otherwise Specified **(Continued)**

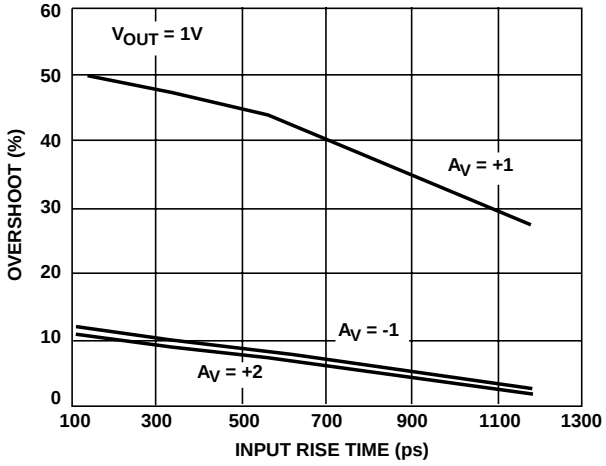


FIGURE 33. OVERSHOOT vs INPUT RISE TIME

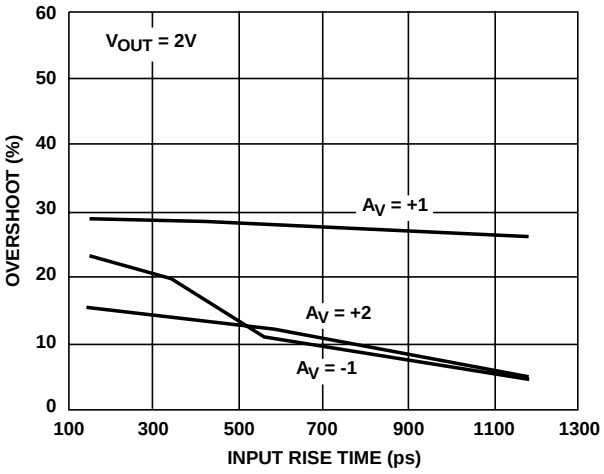


FIGURE 34. OVERSHOOT vs INPUT RISE TIME

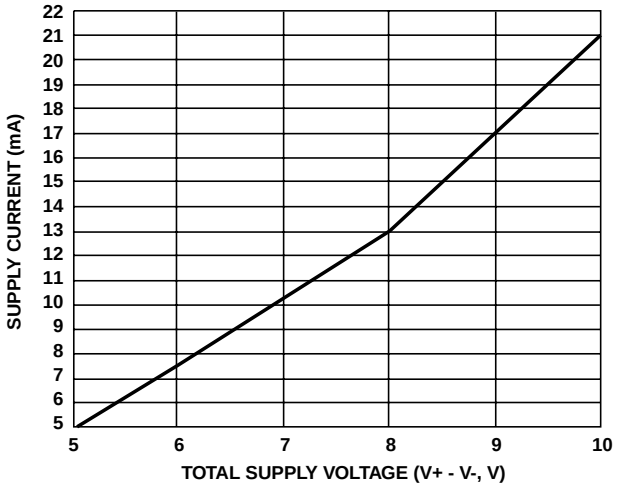


FIGURE 35. SUPPLY CURRENT vs SUPPLY VOLTAGE

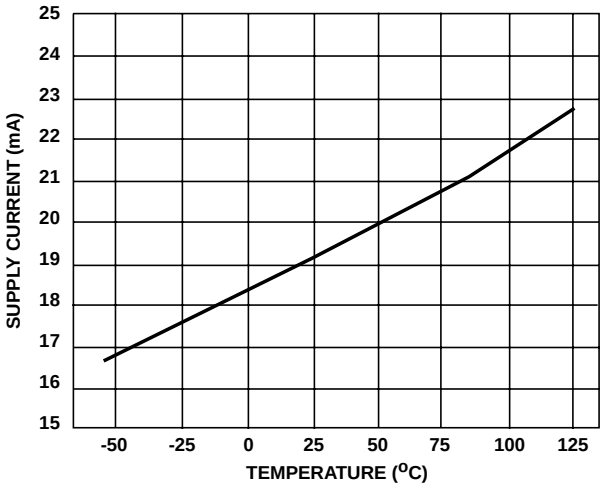


FIGURE 36. SUPPLY CURRENT vs TEMPERATURE

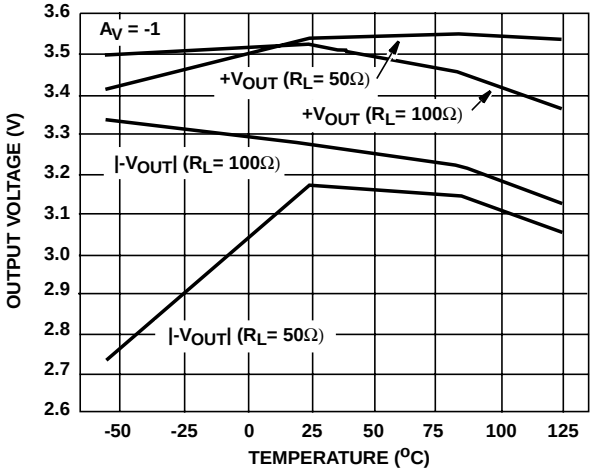


FIGURE 37. OUTPUT VOLTAGE vs TEMPERATURE

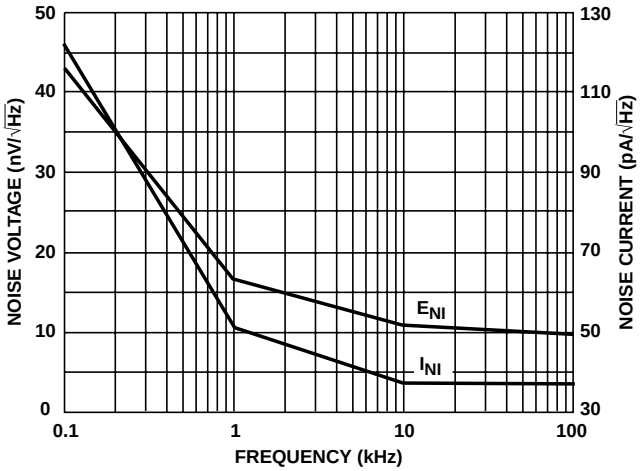


FIGURE 38. INPUT NOISE CHARACTERISTICS

Die Characteristics

DIE DIMENSIONS:

63 mils x 44 mils x 19 mils
1600µm x 1130µm 483µm

METALLIZATION:

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

Type: Metal 2: AlCu (2%)
Thickness: Metal 2: 16kÅ ±0.8kÅ

PASSIVATION:

Type: Nitride
Thickness: 4kÅ ±0.5kÅ

TRANSISTOR COUNT:

52

SUBSTRATE POTENTIAL (Powered Up):

Floating (Recommend Connection to V-)

Metallization Mask Layout

HFA1112