Data Sheet September 1998 File Number 3654.4

Triple, 125MHz Video Amplifier

The HA5013 is a low cost triple amplifier optimized for RGB video applications and gains between 1 and 10. It is a current feedback amplifier and thus yields less bandwidth degradation at high closed loop gains than voltage feedback amplifiers.

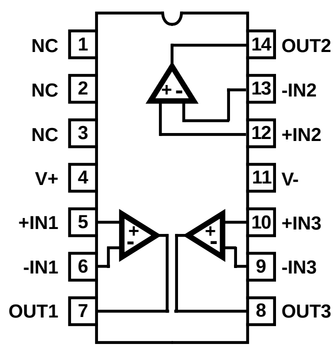
The low differential gain and phase, 0.1dB gain flatness, and ability to drive two back terminated 75Ω cables, make this amplifier ideal for demanding video applications.

The current feedback design allows the user to take advantage of the amplifier's bandwidth dependency on the feedback resistor.

The performance of the HA5013 is very similar to the popular Intersil HA-5020 single video amplifier.

Pinout

HA5013
(PDIP, SOIC)
TOP VIEW



Features

- Wide Unity Gain Bandwidth 125MHz
- Slew Rate 475V/µs
- Input Offset Voltage 800µV
- Differential Gain 0.03%
- Differential Phase . . . . 0.03 Degrees
- Supply Current (Per Amplifier) 7.5mA
- ESD Protection. 4000V
- Guaranteed Specifications at ±5V Supplies
- Low Cost

Applications

- PC Add-On Multimedia Boards
- Flash A/D Driver
- Color Image Scanners
- CCD Cameras and Systems
- RGB Cable Driver
- RGB Video Preamp
- PC Video Conferencing

Ordering Information

PART NUMBER	TEMP. RANGE (^oC)	PACKAGE	PKG. NO.
HA5013IP	-40 to 85	14 Ld PDIP	E14.3
HA5013IB	-40 to 85	14 Ld SOIC	M14.15
HA5025EVAL	High Speed Op Amp DIP Evaluation Board		

Absolute Maximum Ratings

Voltage Between V+ and V- Terminals 36V
DC Input Voltage . . . . $\pm V_{SUPPLY}$
Differential Input Voltage 10V
Output Current (Note 2) . . . . Short Circuit Protected
ESD Rating (Note 4)
Human Body Model (Per MIL-STD-883 Method 3015.7) 2000V

Operating Conditions

Temperature Range . . . . -40^oC to 85^oC
Supply Voltage Range (Typical) . . . . ±4.5V to ±15V

Thermal Information

Thermal Resistance (Typical, Note 1)	θ_{JA} ($^oC/W$)
PDIP Package	100
SOIC Package	120

Maximum Junction Temperature (Die Only, Note 3) . . . . 175^oC
Maximum Junction Temperature (Plastic Package, Note 3) . . . 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.

NOTES:

1. θ_{JA} is measured with the component mounted on an evaluation PC board in free air.
2. Output is protected for short circuits to ground. Brief short circuits to ground will not degrade reliability, however, continuous (100% duty cycle) output current should not exceed 15mA for maximum reliability.
3. Maximum power dissipation, including output load, must be designed to maintain junction temperature below 175^oC for die, and below 150^oC for plastic packages. See Application Information section for safe operating area information.
4. The non-inverting input of unused amplifiers must be connected to GND.

Electrical Specifications

V_{SUPPLY} = ±5V, R_F = 1kΩ, A_V = +1, R_L = 400Ω, C_L ≤10pF, Unless Otherwise Specified

PARAMETER	TEST CONDITIONS	(NOTE 9) TEST LEVEL	TEMP. (^oC)	MIN	TYP	MAX	UNITS
INPUT CHARACTERISTICS							
Input Offset Voltage (V_{IO})		A	25	-	0.8	3	mV
		A	Full	-	-	5	mV
Delta V_{IO} Between Channels		A	Full	-	1.2	3.5	mV
Average Input Offset Voltage Drift		B	Full	-	5	-	µV/^oC
V_{IO} Common Mode Rejection Ratio	V_{CM} = ±2.5V (Note 5)	A	25	53	-	-	dB
		A	Full	50	-	-	dB
V_{IO} Power Supply Rejection Ratio	±3.5V ≤ V_S ≤ ±6.5V	A	25	60	-	-	dB
		A	Full	55	-	-	dB
Input Common Mode Range	V_{CM} = ±2.5V (Note 5)	A	Full	±2.5	-	-	V
Non-Inverting Input (+IN) Current		A	25	-	3	8	µA
		A	Full	-	-	20	µA
+IN Common Mode Rejection ($+I_{BCMR} = \frac{1}{+R_{IN}}$)	V_{CM} = ±2.5V (Note 5)	A	25	-	-	0.15	µA/V
		A	Full	-	-	0.5	µA/V
+IN Power Supply Rejection	±3.5V ≤ V_S ≤ ±6.5V	A	25	-	-	0.1	µA/V
		A	Full	-	-	0.3	µA/V
Inverting Input (-IN) Current		A	25, 85	-	4	12	µA
		A	-40	-	10	30	µA
Delta - IN BIAS Current Between Channels		A	25, 85	-	6	15	µA
		A	-40	-	10	30	µA

Electrical Specifications V_{SUPPLY} = ±5V, R_F = 1kΩ, A_V = +1, R_L = 400Ω, C_L ≤10pF, Unless Otherwise Specified **(Continued)**

PARAMETER	TEST CONDITIONS	(NOTE 9) TEST LEVEL	TEMP. (^{o}C)	MIN	TYP	MAX	UNITS
-IN Common Mode Rejection	V_{CM} = ±2.5V (Note 5)	A	25	-	-	0.4	μA/V
		A	Full	-	-	1.0	μA/V
-IN Power Supply Rejection	±3.5V ≤ V_S ≤ ±6.5V	A	25	-	-	0.2	μA/V
		A	Full	-	-	0.5	μA/V
Input Noise Voltage	f = 1kHz	B	25	-	4.5	-	nV/√Hz
+Input Noise Current	f = 1kHz	B	25	-	2.5	-	pA/√Hz
-Input Noise Current	f = 1kHz	B	25	-	25.0	-	pA/√Hz
TRANSFER CHARACTERISTICS							
Transimpedence	V_{OUT} = ±2.5V (Note 11)	A	25	1.0	-	-	MΩ
		A	Full	0.85	-	-	MΩ
Open Loop DC Voltage Gain	R_L = 400Ω, V_{OUT} = ±2.5V	A	25	70	-	-	dB
		A	Full	65	-	-	dB
Open Loop DC Voltage Gain	R_L = 100Ω, V_{OUT} = ±2.5V	A	25	50	-	-	dB
		A	Full	45	-	-	dB
OUTPUT CHARACTERISTICS							
Output Voltage Swing	R_L = 150Ω	A	25	±2.5	±3.0	-	V
		A	Full	±2.5	±3.0	-	V
Output Current	R_L = 150Ω	B	Full	±16.6	±20.0	-	mA
Short Circuit Output Current	V_{IN} = ±2.5V, V_{OUT} = 0V	A	Full	±40	±60	-	mA
POWER SUPPLY CHARACTERISTICS							
Supply Voltage Range		A	25	5	-	15	V
Quiescent Supply Current		A	Full	-	7.5	10	mA/Op Amp
AC CHARACTERISTICS A_V = +1							
Slew Rate	Note 6	B	25	275	350	-	V/μs
Full Power Bandwidth (Note 7)		B	25	22	28	-	MHz
Rise Time (Note 8)	V_{OUT} = 1V, R_L = 100Ω	B	25	-	6	-	ns
Fall Time (Note 8)	V_{OUT} = 1V, R_L = 100Ω	B	25	-	6	-	ns
Propagation Delay (Note 8)	V_{OUT} = 1V, R_L = 100Ω	B	25	-	6	-	ns
Overshoot		B	25	-	4.5	-	%
-3dB Bandwidth	V_{OUT} = 100mV	B	25	-	125	-	MHz
Settling Time	To 1%, 2V Output Step	B	25	-	50	-	ns
Settling Time	To 0.25%, 2V Output Step	B	25	-	75	-	ns
AC CHARACTERISTICS A_V = +2, R_F = 681Ω							
Slew Rate	Note 6	B	25	-	475	-	V/μs

Electrical Specifications V_{SUPPLY} = ±5V, R_F = 1kΩ, A_V = +1, R_L = 400Ω, C_L ≤10pF, Unless Otherwise Specified **(Continued)**

PARAMETER	TEST CONDITIONS	(NOTE 9) TEST LEVEL	TEMP. (^oC)	MIN	TYP	MAX	UNITS
Full Power Bandwidth (Note 7)		B	25	-	26	-	MHz
Rise Time (Note 8)	V_{OUT} = 1V, R_L = 100Ω	B	25	-	6	-	ns
Fall Time (Note 8)	V_{OUT} = 1V, R_L = 100Ω	B	25	-	6	-	ns
Propagation Delay (Note 8)	V_{OUT} = 1V, R_L = 100Ω	B	25	-	6	-	ns
Overshoot		B	25	-	12	-	%
-3dB Bandwidth	V_{OUT} = 100mV	B	25	-	95	-	MHz
Settling Time	To 1%, 2V Output Step	B	25	-	50	-	ns
Settling Time	To 0.25%, 2V Output Step	B	25	-	100	-	ns
Gain Flatness	5MHz	B	25	-	0.02	-	dB
	20MHz	B	25	-	0.07	-	dB
AC CHARACTERISTICS A_V = +10, R_F = 383Ω							
Slew Rate	Note 6	B	25	350	475	-	V/µs
Full Power Bandwidth (Note 7)		B	25	28	38	-	MHz
Rise Time (Note 8)	V_{OUT} = 1V, R_L = 100Ω	B	25	-	8	-	ns
Fall Time (Note 8)	V_{OUT} = 1V, R_L = 100Ω	B	25	-	9	-	ns
Propagation Delay (Note 8)	V_{OUT} = 1V, R_L = 100Ω	B	25	-	9	-	ns
Overshoot		B	25	-	1.8	-	%
-3dB Bandwidth	V_{OUT} = 100mV	B	25	-	65	-	MHz
Settling Time	To 1%, 2V Output Step	B	25	-	75	-	ns
	To 0.1%, 2V Output Step	B	25	-	130	-	ns
VIDEO CHARACTERISTICS							
Differential Gain	R_L = 150Ω, (Note 10)	B	25	-	0.03	-	%
Differential Phase	R_L = 150Ω, (Note 10)	B	25	-	0.03	-	Degrees

NOTES:

5. At -40^{o}C Product is tested at V_{CM} = ±2.25V because Short Test Duration does not allow self heating.
6. V_{OUT} switches from -2V to +2V, or from +2V to -2V. Specification is from the 25% to 75% points.
7. $FPBW = \frac{\text{Slew Rate}}{2\pi V_{PEAK}}$; $V_{PEAK} = 2V$.
8. Measured from 10% to 90% points for rise/fall times; from 50% points of input and output for propagation delay.
9. A. Production Tested; B. Typical or Guaranteed Limit based on characterization; C. Design Typical for information only.
10. Measured with a VM700A video tester using an NTC-7 composite VITS.
11. At -40^{o}C Product is tested at V_{OUT} = ±2.25V because Short Test Duration does not allow self heating.

Test Circuits and Waveforms

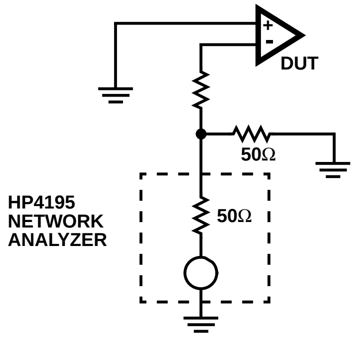


FIGURE 1. TEST CIRCUIT FOR TRANSIMPEDANCE MEASUREMENTS

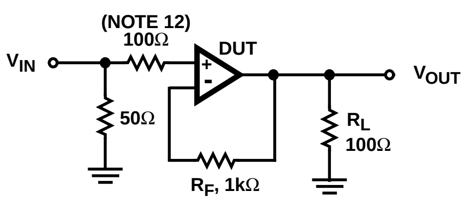


FIGURE 2. SMALL SIGNAL PULSE RESPONSE CIRCUIT

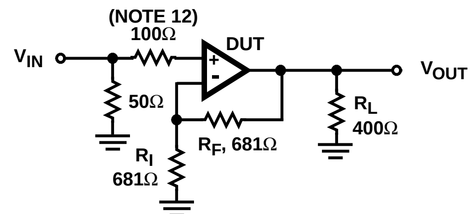
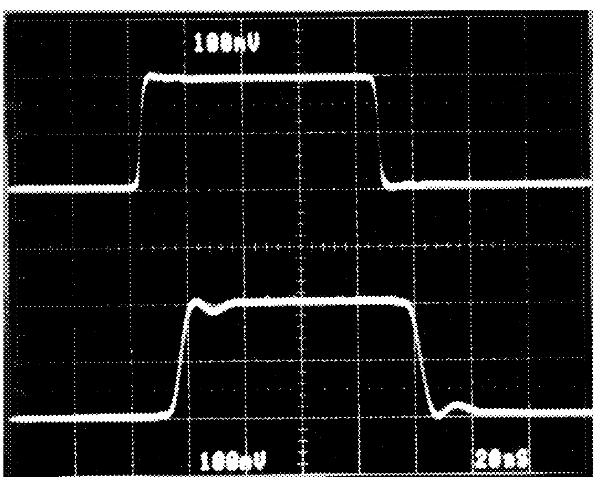


FIGURE 3. LARGE SIGNAL PULSE RESPONSE CIRCUIT

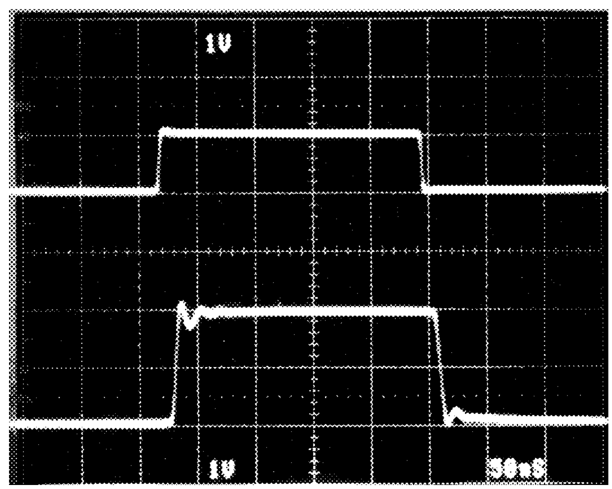
NOTE:

12. A series input resistor of ≥100Ω is recommended to limit input currents in case input signals are present before the HA5013 is powered up.



Vertical Scale: V_{IN} = 100mV/Div., V_{OUT} = 100mV/Div.
Horizontal Scale: 20ns/Div.

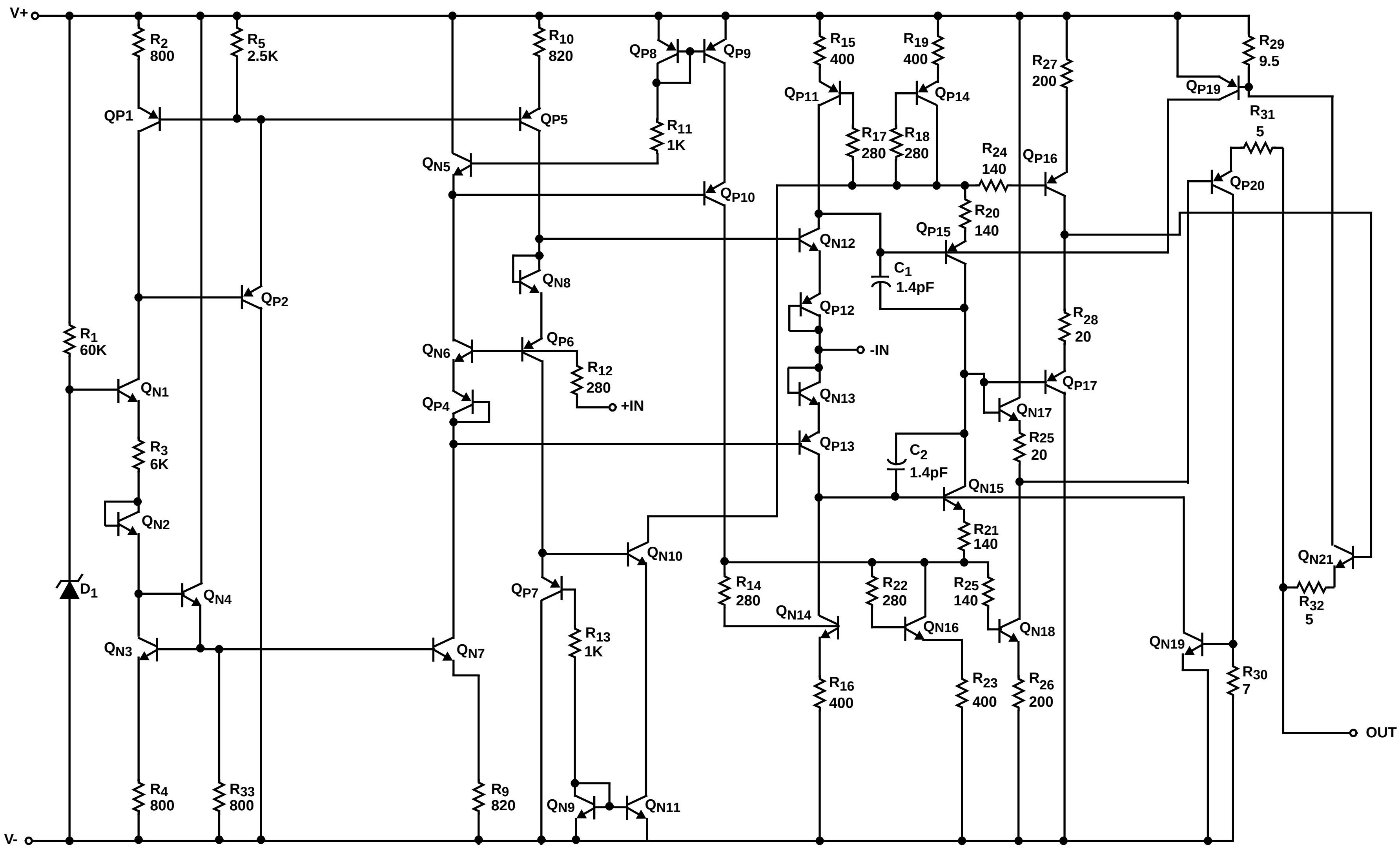
FIGURE 4. SMALL SIGNAL RESPONSE



Vertical Scale: V_{IN} = 1V/Div., V_{OUT} = 1V/Div.
Horizontal Scale: 50ns/Div.

FIGURE 5. LARGE SIGNAL RESPONSE

Schematic (One Amplifier of Three)



Application Information

Optimum Feedback Resistor

The plots of inverting and non-inverting frequency response, see Figure 8 and Figure 9 in the typical performance section, illustrate the performance of the HA5013 in various closed loop gain configurations. Although the bandwidth dependency on closed loop gain isn't as severe as that of a voltage feedback amplifier, there can be an appreciable decrease in bandwidth at higher gains. This decrease may be minimized by taking advantage of the current feedback amplifier's unique relationship between bandwidth and R_F. All current feedback amplifiers require a feedback resistor, even for unity gain applications, and R_F, in conjunction with the internal compensation capacitor, sets the dominant pole of the frequency response. Thus, the amplifier's bandwidth is inversely proportional to R_F. The HA5013 design is optimized for a 1000Ω R_F at a gain of +1. Decreasing R_F in a unity gain application decreases stability, resulting in excessive peaking and overshoot. At higher gains the amplifier is more stable, so R_F can be decreased in a trade-off of stability for bandwidth.

The table below lists recommended R_F values for various gains, and the expected bandwidth.

GAIN (A_{CL})	R_F (Ω)	BANDWIDTH (MHz)
-1	750	100
+1	1000	125
+2	68f1	95
+5	1000	52
+10	383	65
-10	750	22

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. If leaded components are used the leads must be kept short especially for the power supply decoupling components and those components connected to the inverting input.

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

A ground plane is strongly recommended to control noise. Care must also be taken to minimize the capacitance to ground seen by the amplifier's inverting input (-IN). The larger this capacitance, the worse the gain peaking, resulting in pulse overshoot and possible instability. It is recommended that the ground plane be removed under traces connected to -IN, and that connections to -IN be kept as short as possible to minimize the capacitance from this node to ground.

Driving Capacitive Loads

Capacitive loads 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 an isolation resistor (R) in series with the output as shown in Figure 6.

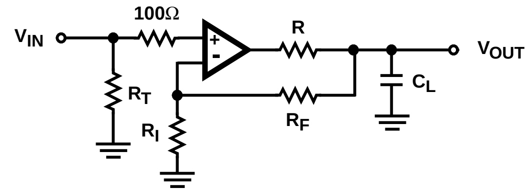


FIGURE 6. PLACEMENT OF THE OUTPUT ISOLATION RESISTOR, R

The selection criteria for the isolation resistor is highly dependent on the load, but 27Ω has been determined to be a good starting value.

Power Dissipation Considerations

Due to the high supply current inherent in triple amplifiers, care must be taken to insure that the maximum junction temperature (T_J, see Absolute Maximum Ratings) is not exceeded. Figure 7 shows the maximum ambient temperature versus supply voltage for the available package styles (PDIP, SOIC). At V_S = ±5V quiescent operation both package styles may be operated over the full industrial range of -40°C to 85°C. It is recommended that thermal calculations, which take into account output power, be performed by the designer.

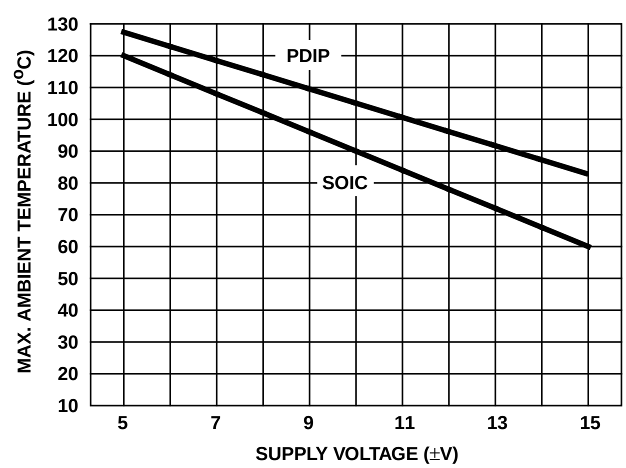


FIGURE 7. MAXIMUM OPERATING AMBIENT TEMPERATURE vs SUPPLY VOLTAGE

Typical Performance Curves V_{SUPPLY} = ±5V, A_V = +1, R_F = 1kΩ, R_L = 400Ω, T_A = 25°C, Unless Otherwise Specified

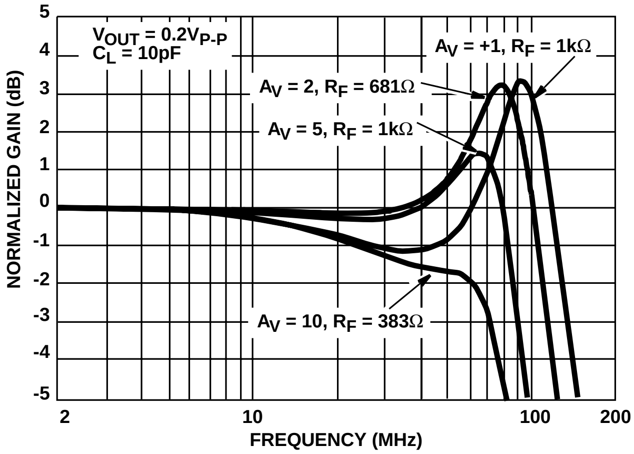


FIGURE 8. NON-INVERTING FREQUENCY RESPONSE

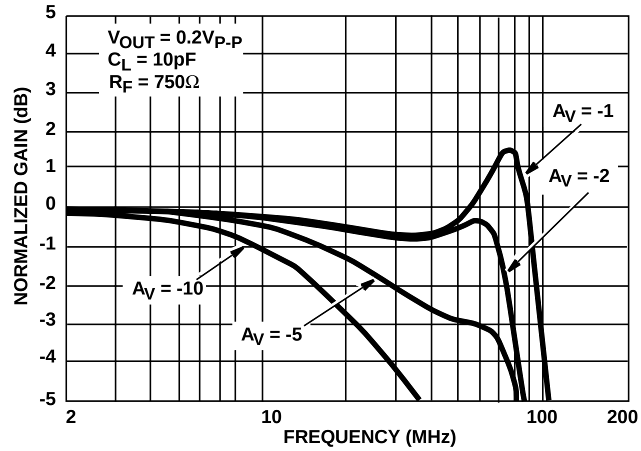


FIGURE 9. INVERTING FREQUENCY RESPONSE

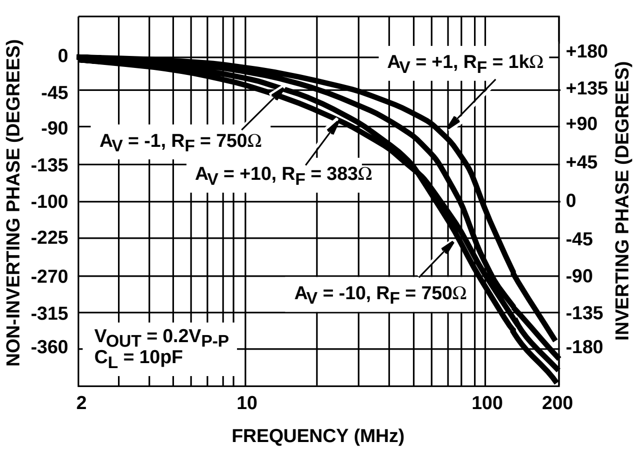


FIGURE 10. PHASE RESPONSE AS A FUNCTION OF FREQUENCY

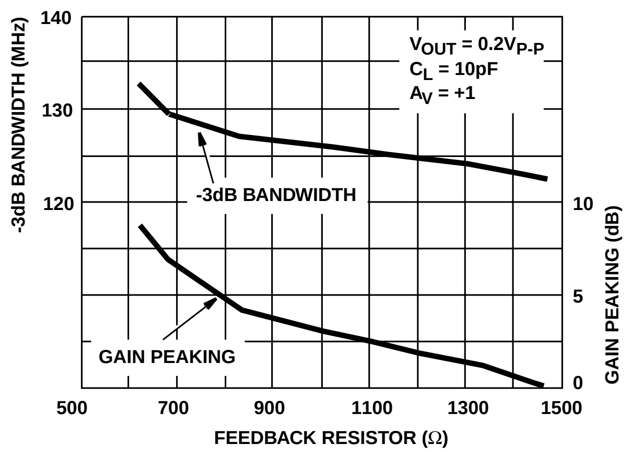


FIGURE 11. BANDWIDTH AND GAIN PEAKING vs FEEDBACK RESISTANCE

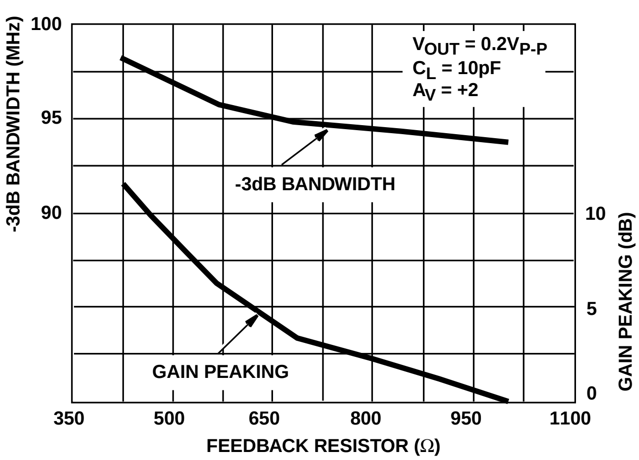


FIGURE 12. BANDWIDTH AND GAIN PEAKING vs FEEDBACK RESISTANCE

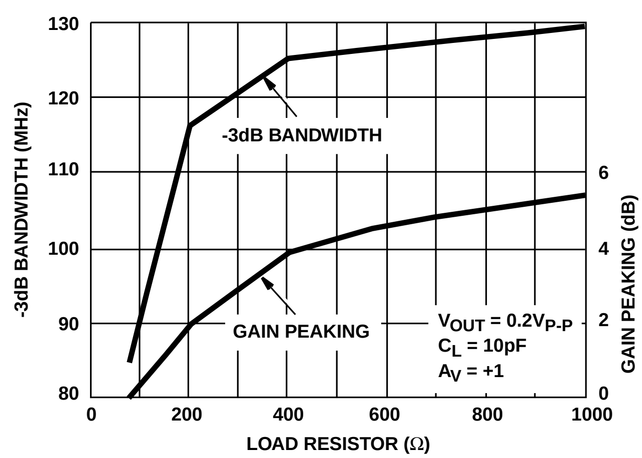


FIGURE 13. BANDWIDTH AND GAIN PEAKING vs LOAD RESISTANCE

Typical Performance Curves V_{SUPPLY} = ±5V, A_V = +1, R_F = 1kΩ, R_L = 400Ω, T_A = 25°C, Unless Otherwise Specified **(Continued)**

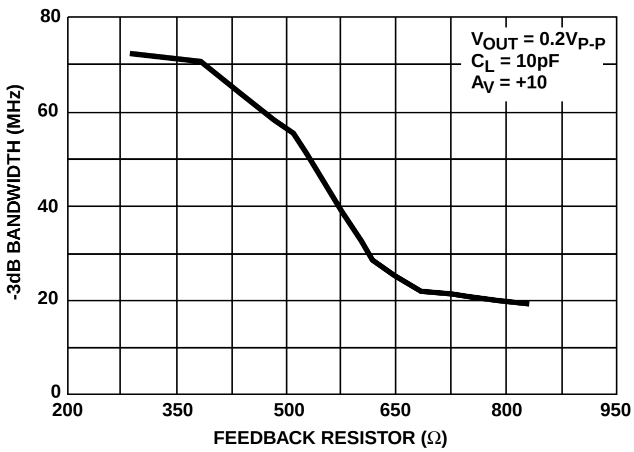


FIGURE 14. BANDWIDTH vs FEEDBACK RESISTANCE

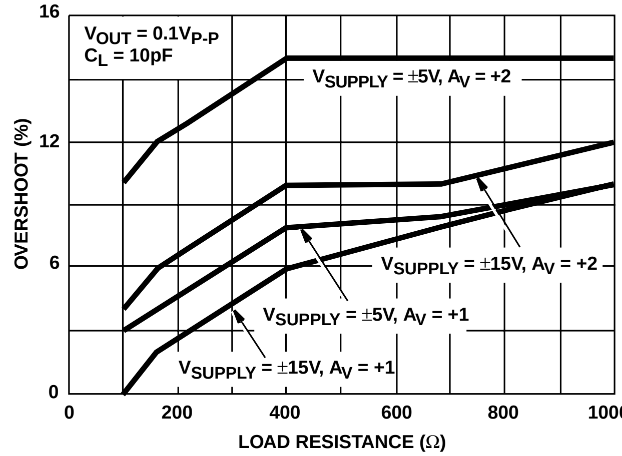


FIGURE 15. SMALL SIGNAL OVERSHOOT vs LOAD RESISTANCE

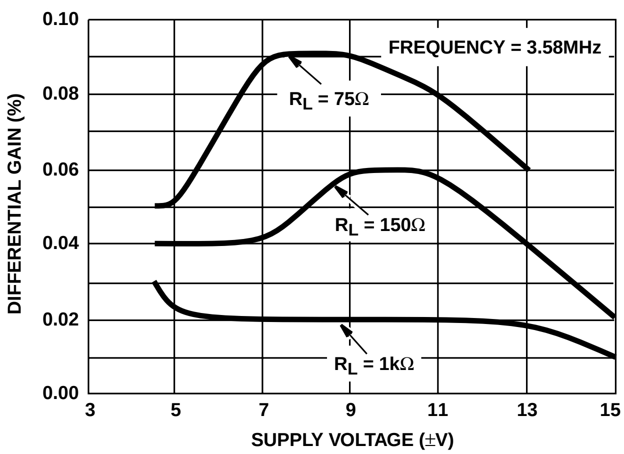


FIGURE 16. DIFFERENTIAL GAIN vs SUPPLY VOLTAGE

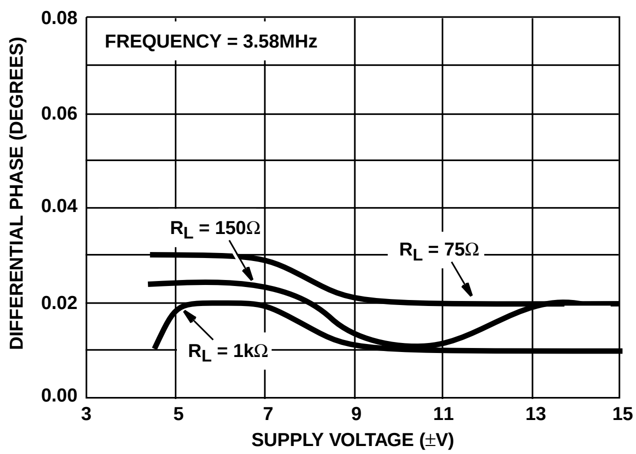


FIGURE 17. DIFFERENTIAL PHASE vs SUPPLY VOLTAGE

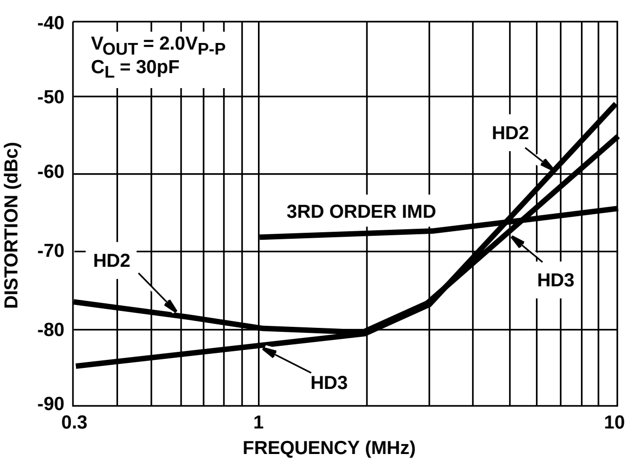


FIGURE 18. DISTORTION vs FREQUENCY

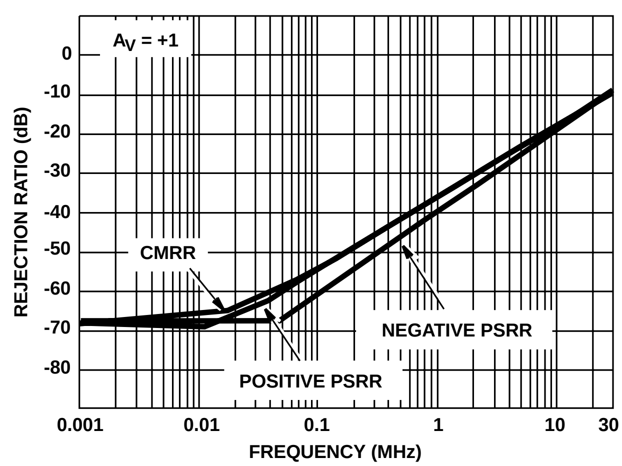


FIGURE 19. REJECTION RATIOS vs FREQUENCY

Typical Performance Curves V_{SUPPLY} = ±5V, A_V = +1, R_F = 1kΩ, R_L = 400Ω, T_A = 25°C, Unless Otherwise Specified **(Continued)**

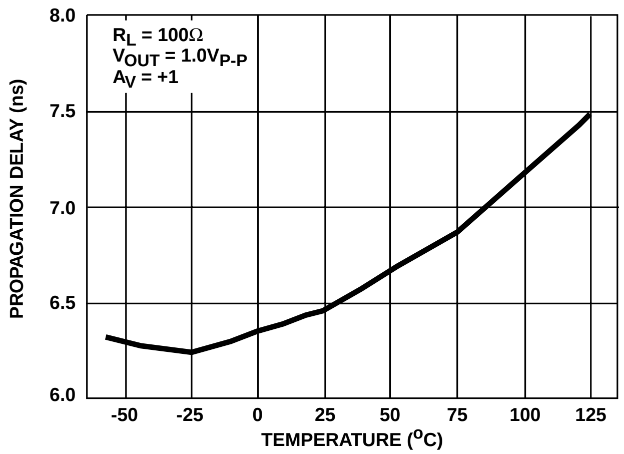


FIGURE 20. PROPAGATION DELAY vs TEMPERATURE

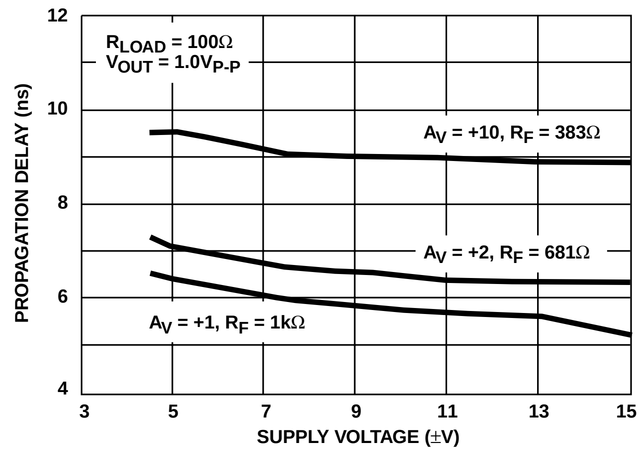


FIGURE 21. PROPAGATION DELAY vs SUPPLY VOLTAGE

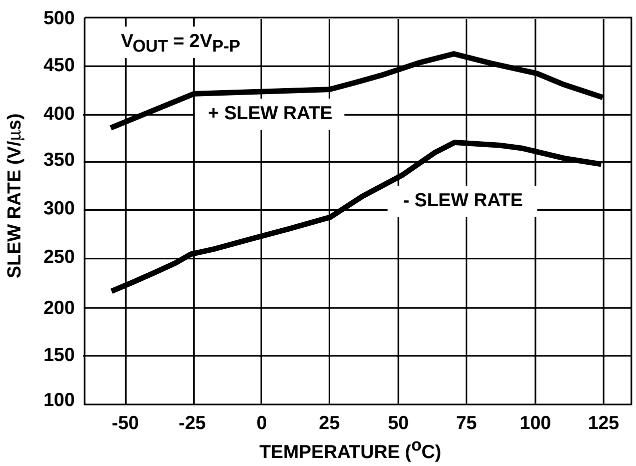


FIGURE 22. SLEW RATE vs TEMPERATURE

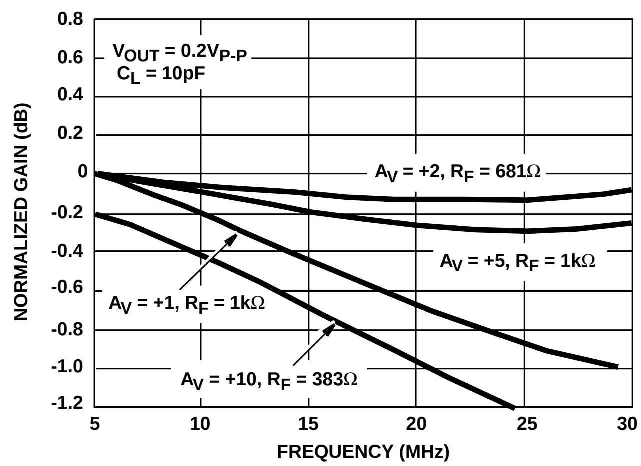


FIGURE 23. NON-INVERTING GAIN FLATNESS vs FREQUENCY

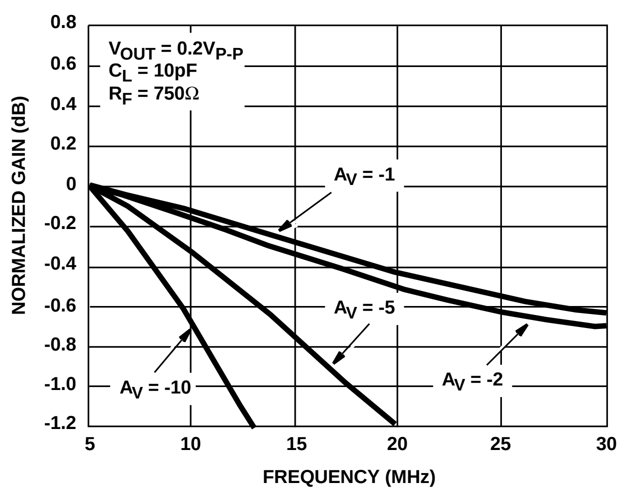


FIGURE 24. INVERTING GAIN FLATNESS vs FREQUENCY

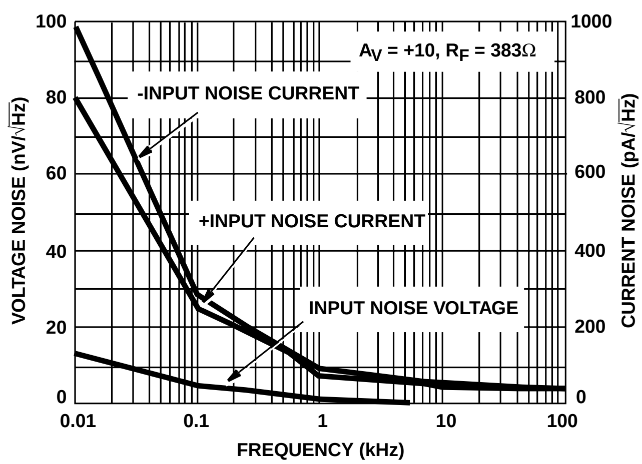


FIGURE 25. INPUT NOISE CHARACTERISTICS

Typical Performance Curves

V_{SUPPLY} = ±5V, A_V = +1, R_F = 1kΩ, R_L = 400Ω, T_A = 25°C, Unless Otherwise Specified **(Continued)**

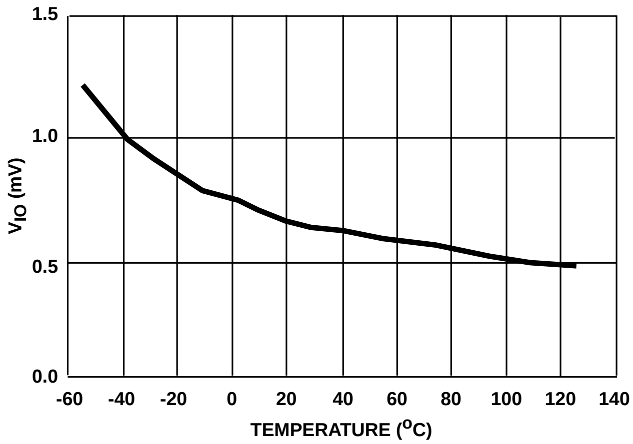


FIGURE 26. INPUT OFFSET VOLTAGE vs TEMPERATURE

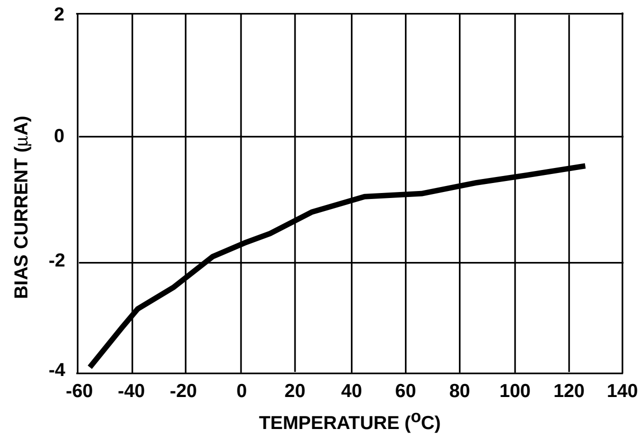


FIGURE 27. +INPUT BIAS CURRENT vs TEMPERATURE

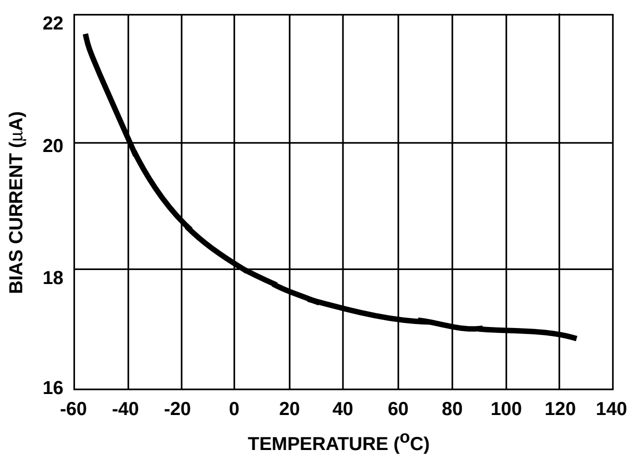


FIGURE 28. -INPUT BIAS CURRENT vs TEMPERATURE

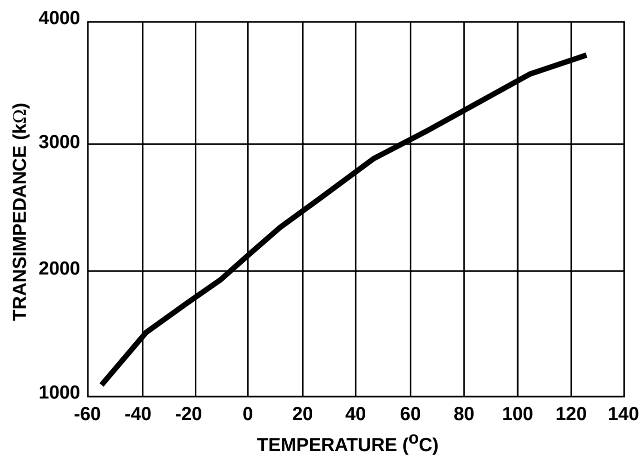


FIGURE 29. TRANSIMPEDANCE vs TEMPERATURE

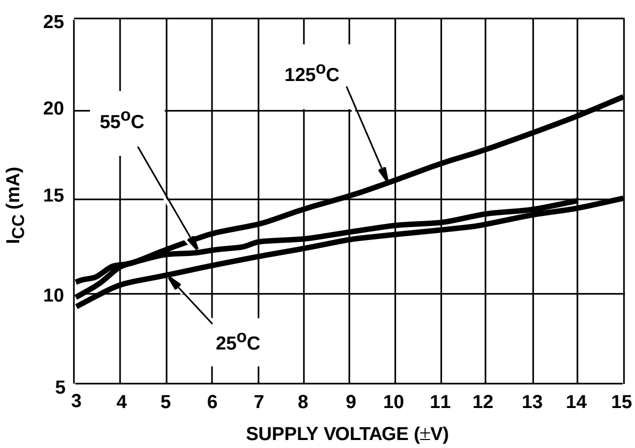


FIGURE 30. SUPPLY CURRENT vs SUPPLY VOLTAGE

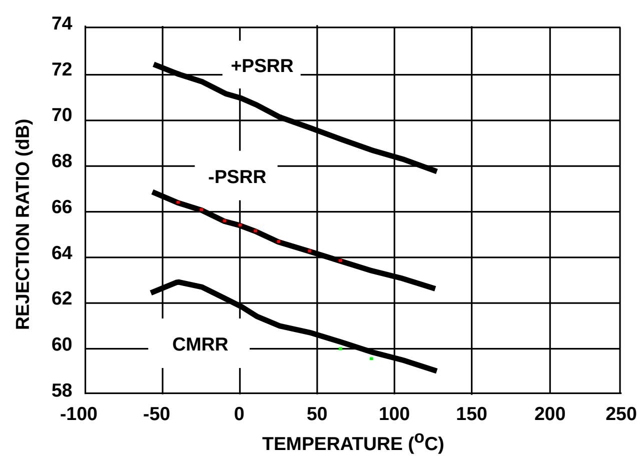


FIGURE 31. REJECTION RATIO vs TEMPERATURE

Typical Performance Curves
V_{SUPPLY} = ±5V, A_V = +1, R_F = 1kΩ, R_L = 400Ω, T_A = 25°C, Unless Otherwise Specified **(Continued)**

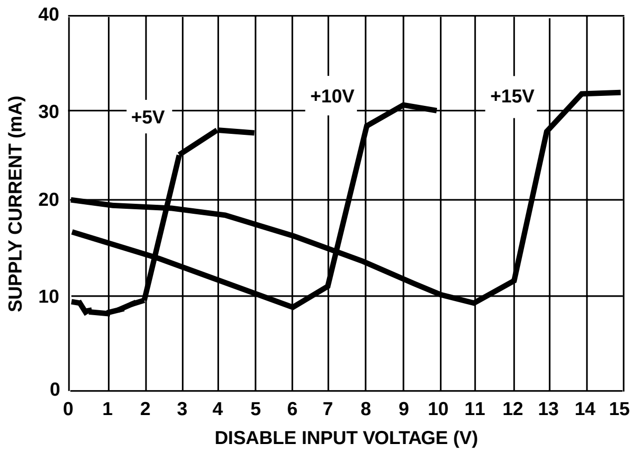


FIGURE 32. SUPPLY CURRENT vs DISABLE INPUT VOLTAGE

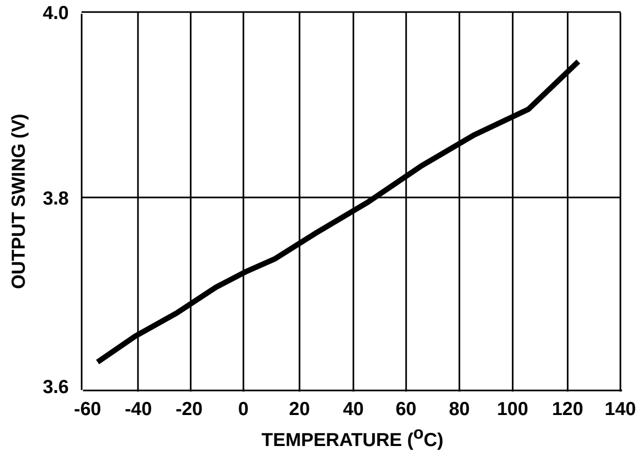


FIGURE 33. OUTPUT SWING vs TEMPERATURE

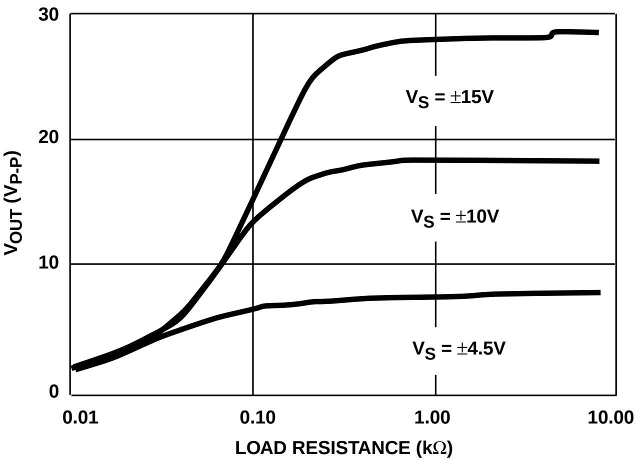


FIGURE 34. OUTPUT SWING vs LOAD RESISTANCE

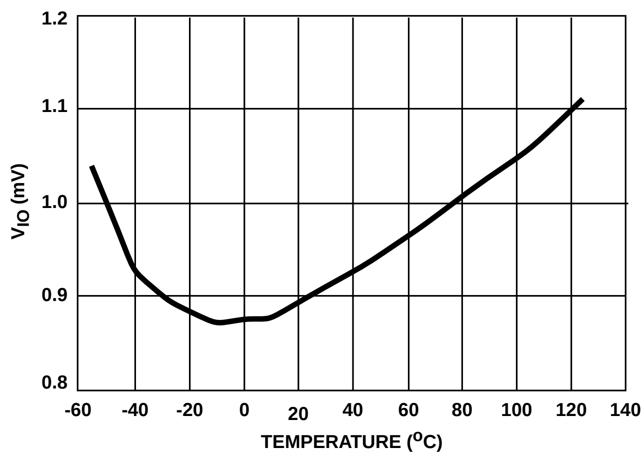


FIGURE 35. INPUT OFFSET VOLTAGE CHANGE BETWEEN CHANNELS vs TEMPERATURE

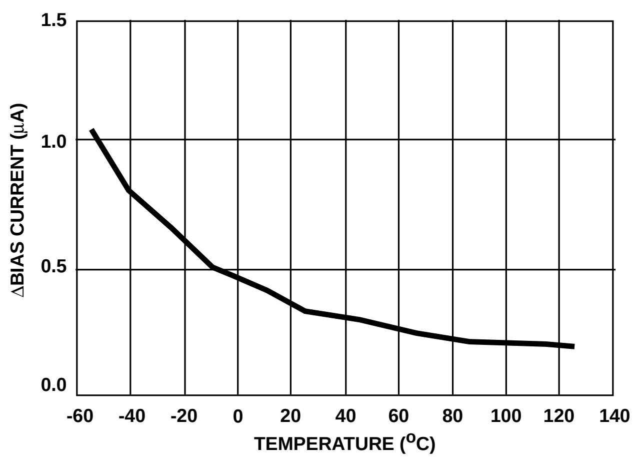


FIGURE 36. INPUT BIAS CURRENT CHANGE BETWEEN CHANNELS vs TEMPERATURE

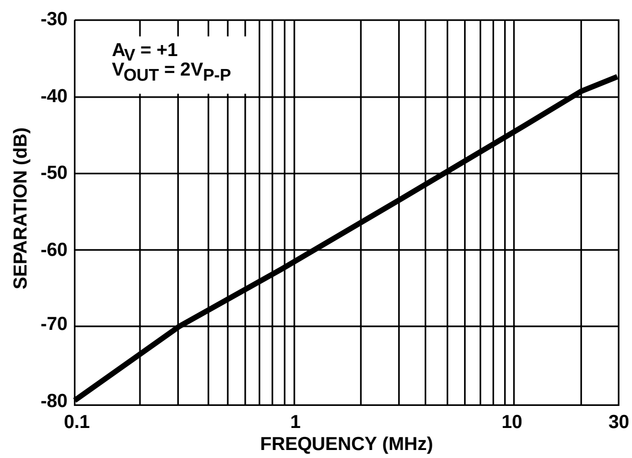


FIGURE 37. CHANNEL SEPARATION vs FREQUENCY

Typical Performance Curves V_{SUPPLY} = ±5V, A_V = +1, R_F = 1kΩ, R_L = 400Ω, T_A = 25^{o}C, Unless Otherwise Specified **(Continued)**

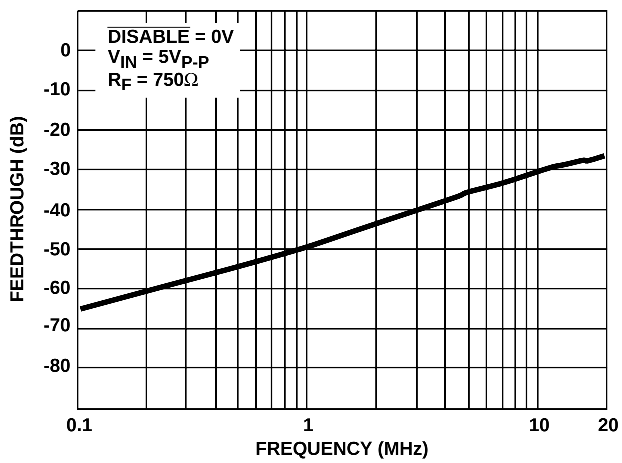


FIGURE 38. DISABLE FEEDTHROUGH vs FREQUENCY

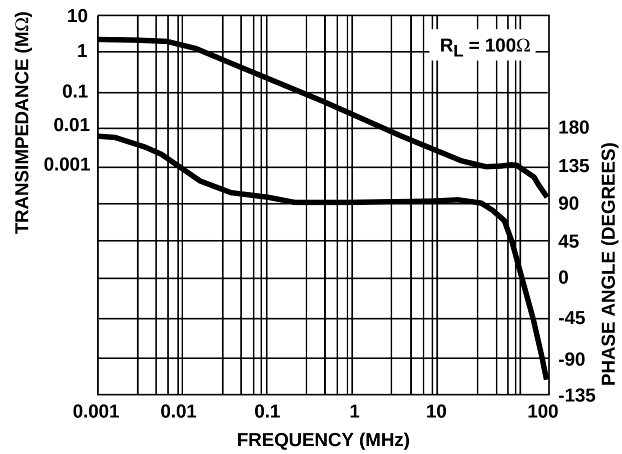


FIGURE 39. TRANSIMPEDANCE vs FREQUENCY

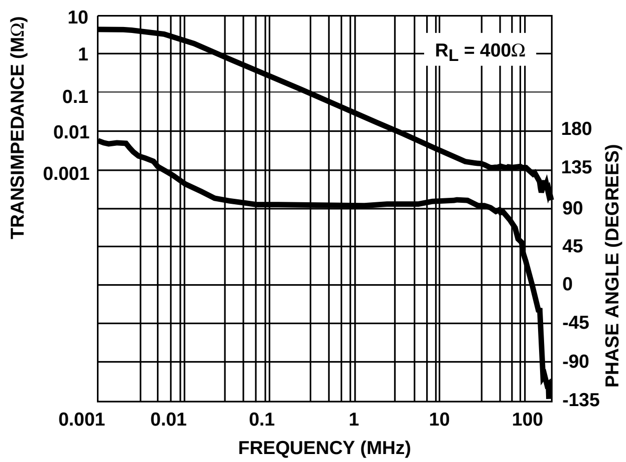


FIGURE 40. TRANSIMPEDENCE vs FREQUENCY

Die Characteristics

DIE DIMENSIONS:

2010µm x 3130µm x 483µm

METALLIZATION:

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

Type: Metal 2: AlCu (1%)
Thickness: Metal 2: 16kÅ ±0.8kÅ

SUBSTRATE POTENTIAL

Unbiased

PASSIVATION:

Type: Nitride
Thickness: 4kÅ ±0.4kÅ

TRANSISTOR COUNT:

248

PROCESS:

High Frequency Bipolar Dielectric Isolation

Metallization Mask Layout

HA5013