# HS-1100RH

Radiation Hardened, Ultra High Speed Current Feedback Amplifier

FN4100
Rev 2.00
August 1999

The HS-1100RH is a radiation hardened high speed, wideband, fast settling current feedback amplifier. Built with Intersil's proprietary, complementary bipolar UHF-1 (DI bonded wafer) process, it is the fastest monolithic amplifier available from any semiconductor manufacturer. These devices are QML approved and are processed and screened in full compliance with MIL-PRF-38535.

The HS-1100RH's wide bandwidth, fast settling characteristic, and low output impedance make this amplifier ideal for driving fast A/D converters.

Component and composite video systems will also benefit from this amplifier's performance, as indicated by the excellent gain flatness, and 0.03%/0.05 Deg. Differential Gain/Phase specifications ($R_L$ = 75Ω).

**Specifications for Rad Hard QML devices are controlled by the Defense Supply Center in Columbus (DSCC). The SMD numbers listed here must be used when ordering.**

**Detailed Electrical Specifications for these devices are contained in SMD 5962-94676. A "hot-link" is provided on our homepage for downloading.
http://www.intersil.com/spacedefense/space.htm**

## Ordering Information

| ORDERING NUMBER | INTERNAL MKT. NUMBER | TEMP. RANGE ($^oC$) |
|---|---|---|
| 5962F9467602VPA | HS7-1100RH-Q | -55 to 125 |
| 5962F9467602VPC | HS7B-1100RH-Q | -55 to 125 |
| HFA1100IJ (Sample) | HFA1100IJ | -40 to 85 |
| HFA11XXEVAL | Evaluation Board | |

## Features

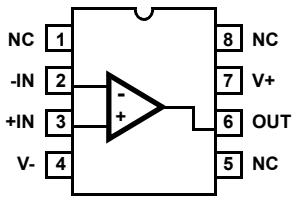
- Electrically Screened to SMD # 5962-94676
- QML Qualified per MIL-PRF-38535 Requirements
- Low Distortion (HD3, 30MHz) . . . . . -84dBc (Typ)
- Wide -3dB Bandwidth. . . . . 850MHz (Typ)
- Very High Slew Rate . . . . . 2300V/μs (Typ)
- Fast Settling (0.1%) . . . . . 11ns (Typ)
- Excellent Gain Flatness (to 50MHz). . . . . 0.05dB (Typ)
- High Output Current . . . . . 65mA (Typ)
- Fast Overdrive Recovery . . . . . <10ns (Typ)
- Total Gamma Dose . . . . . 300kRAD(Si)
- Latch Up. . . . . None (DI Technology)

## Applications

- Video Switching and Routing
- Pulse and Video Amplifiers
- Wideband Amplifiers
- RF/IF Signal Processing
- Flash A/D Driver
- Imaging Systems

## Pinout

**HS-1100RH
GDIP1-T8 (CERDIP)
OR CDIP2-T8 (SBDIP)**
TOP VIEW



## Typical Applications

### Optimum Feedback Resistor

The enclosed plots of inverting and non-inverting frequency response illustrate the performance of the HS-1100RH in various gains. 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 HS-1100RH design is optimized for a 510Ω $R_F$ 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 (ACL) | $R_F$ (Ω) | BANDWIDTH (MHz) |
|---|---|---|
| -1 | 430 | 580 |
| +1 | 510 | 850 |
| +2 | 360 | 670 |
| +5 | 150 | 520 |
| +10 | 180 | 240 |
| +19 | 270 | 125 |

## 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.

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. To this end, it is recommended that the ground plane be removed under traces connected to -IN, and connections to -IN should be kept as short as possible.

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.

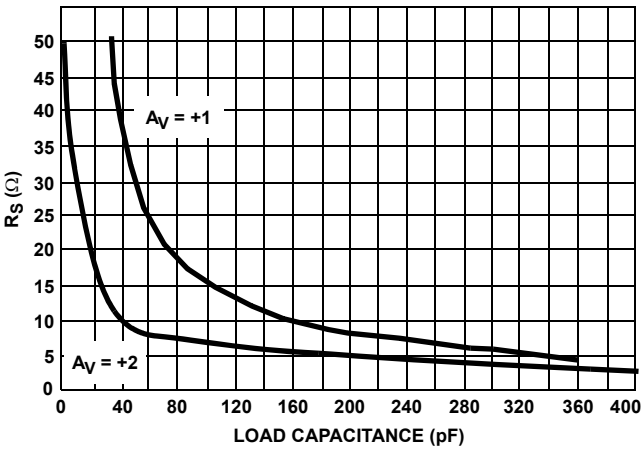



**FIGURE 1. RECOMMENDED SERIES OUTPUT RESISTOR vs LOAD CAPACITANCE**

$R_S$ 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.

## Evaluation Board

The performance of the HS-1100RH may be evaluated using the HFA11XXEVAL Evaluation Board.

The layout and schematic of the board are shown in Figure 2. To order evaluation boards, please contact your local sales office.

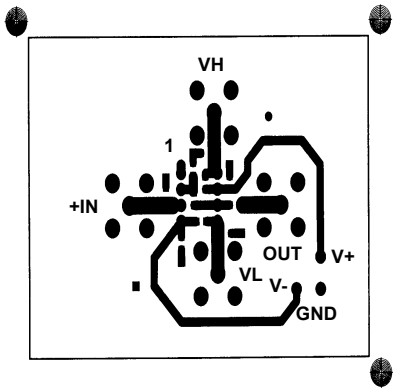



FIGURE 2A. TOP LAYOUT

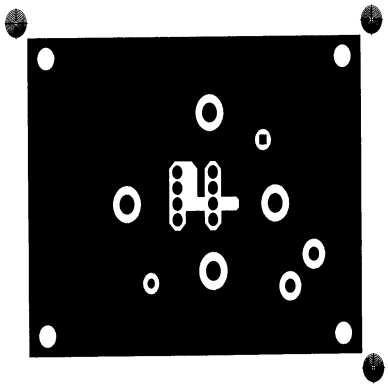


FIGURE 2B. BOTTOM LAYOUT

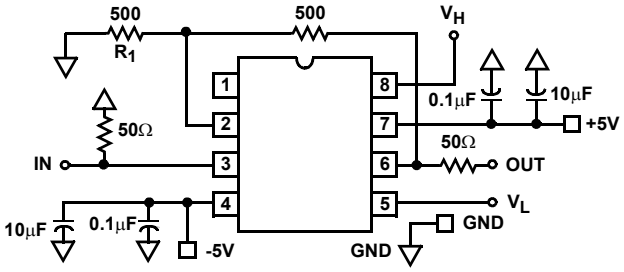



FIGURE 2C. SCHEMATIC

FIGURE 2. EVALUATION BOARD SCHEMATIC AND LAYOUT

## *Typical Performance Characteristics*

Device Characterized at: $V_{SUPPLY}$ = ±5V, $R_F$ = 360Ω, $A_V$ = +2V/V, $R_L$ = 100Ω, Unless Otherwise Specified

| PARAMETERS | CONDITIONS | TEMPERATURE | TYPICAL | UNITS |
|---|---|---|---|---|
| Input Offset Voltage (Note 1) | $V_{CM}$ = 0V | 25°C | 2 | mV |
| Average Offset Voltage Drift | Versus Temperature | Full | 10 | µV/°C |
| $V_{IO}$ CMRR | $\Delta V_{CM}$ = ±2V | 25°C | 46 | dB |
| $V_{IO}$ PSRR | $\Delta V_S$ = ±1.25V | 25°C | 50 | dB |
| +Input Current (Note 1) | $V_{CM}$ = 0V | 25°C | 25 | µA |
| Average +Input Current Drift | Versus Temperature | Full | 40 | nA/°C |
| - Input Current (Note 1) | $V_{CM}$ = 0V | 25°C | 12 | µA |
| Average -Input Current Drift | Versus Temperature | Full | 40 | nA/°C |
| +Input Resistance | $\Delta V_{CM}$ = ±2V | 25°C | 50 | kΩ |
| - Input Resistance | | 25°C | 16 | Ω |
| Input Capacitance | | 25°C | 2.2 | pF |
| Input Noise Voltage (Note 1) | f = 100kHz | 25°C | 4 | nV/√Hz |
| +Input Noise Current (Note 1) | f = 100kHz | 25°C | 18 | pA/√Hz |
| -Input Noise Current (Note 1) | f = 100kHz | 25°C | 21 | pA/√Hz |
| Input Common Mode Range | | Full | ±3.0 | V |
| Open Loop Transimpedance | $A_V$ = -1 | 25°C | 500 | kΩ |

## *Typical Performance Characteristics* (Continued)

Device Characterized at: $V_{SUPPLY}$ = ±5V, $R_F$ = 360Ω, $A_V$ = +2V/V, $R_L$ = 100Ω, Unless Otherwise Specified

| PARAMETERS | CONDITIONS | TEMPERATURE | TYPICAL | UNITS |
|---|---|---|---|---|
| Output Voltage | $A_V$ = -1, $R_L$ = 100Ω | 25°C | ±3.3 | V |
| | $A_V$ = -1, $R_L$ = 100Ω | Full | ±3.0 | V |
| Output Current (Note 1) | $A_V$ = -1, $R_L$ = 50Ω | 25°C to 125°C | ±65 | mA |
| | $A_V$ = -1, $R_L$ = 50Ω | -55°C to 0°C | ±50 | mA |
| DC Closed Loop Output Resistance | | 25°C | 0.1 | W |
| Quiescent Supply Current (Note 1) | $R_L$ = Open | Full | 24 | mA |
| -3dB Bandwidth (Note 1) | $A_V$ = -1, $R_F$ = 430Ω, $V_{OUT}$ = 200m$V_{P-P}$ | 25°C | 580 | MHz |
| | $A_V$ = +1, $R_F$ = 510Ω, $V_{OUT}$ = 200m$V_{P-P}$ | 25°C | 850 | MHz |
| | $A_V$ = +2, $R_F$ = 360Ω, $V_{OUT}$ = 200m$V_{P-P}$ | 25°C | 670 | MHz |
| Slew Rate | $A_V$ = +1, $R_F$ = 510Ω, $V_{OUT}$ = 5$V_{P-P}$ | 25°C | 1500 | V/µs |
| | $A_V$ = +2, $V_{OUT}$ = 5$V_{P-P}$ | 25°C | 2300 | V/µs |
| Full Power Bandwidth | $V_{OUT}$ = 5$V_{P-P}$ | 25°C | 220 | MHz |
| Gain Flatness (Note 1) | To 30MHz, $R_F$ = 510Ω | 25°C | ±0.014 | dB |
| | To 50MHz, $R_F$ = 510Ω | 25°C | ±0.05 | dB |
| | To 100MHz, $R_F$ = 510Ω | 25°C | ±0.14 | dB |
| Linear Phase Deviation (Note 1) | To 100MHz, $R_F$ = 510Ω | 25°C | ±0.6 | Degrees |
| 2nd Harmonic Distortion (Note 1) | 30MHz, $V_{OUT}$ = 2$V_{P-P}$ | 25°C | -55 | dBc |
| | 50MHz, $V_{OUT}$ = 2$V_{P-P}$ | 25°C | -49 | dBc |
| | 100MHz, $V_{OUT}$ = 2$V_{P-P}$ | 25°C | -44 | dBc |
| 3rd Harmonic Distortion (Note 1) | 30MHz, $V_{OUT}$ = 2$V_{P-P}$ | 25°C | -84 | dBc |
| | 50MHz, $V_{OUT}$ = 2$V_{P-P}$ | 25°C | -70 | dBc |
| | 100MHz, $V_{OUT}$ = 2$V_{P-P}$ | 25°C | -57 | dBc |
| 3rd Order Intercept (Note 1) | 100MHz, $R_F$ = 510Ω | 25°C | 30 | dBm |
| 1dB Compression | 100MHz, $R_F$ = 510Ω | 25°C | 20 | dBm |
| Reverse Isolation (S12) | 40MHz, $R_F$ = 510Ω | 25°C | -70 | dB |
| | 100MHz, $R_F$ = 510Ω | 25°C | -60 | dB |
| | 600MHz, $R_F$ = 510Ω | 25°C | -32 | dB |
| Rise and Fall Time | $V_{OUT}$ = 0.5$V_{P-P}$ | 25°C | 500 | ps |
| | $V_{OUT}$ = 2$V_{P-P}$ | 25°C | 800 | ps |
| Overshoot (Note 1) | $V_{OUT}$ = 0.5$V_{P-P}$, Input $t_R/t_F$ = 550ps | 25°C | 11 | % |
| Settling Time (Note 1) | To 0.1%, $V_{OUT}$ = 2V to 0V, $R_F$ = 510Ω | 25°C | 11 | ns |
| | To 0.05%, $V_{OUT}$ = 2V to 0V, $R_F$ = 510Ω | 25°C | 19 | ns |
| | To 0.02%, $V_{OUT}$ = 2V to 0V, $R_F$ = 510Ω | 25°C | 34 | ns |
| Differential Gain | $A_V$ = +2, $R_L$ = 75Ω, NTSC | 25°C | 0.03 | % |
| Differential Phase | $A_V$ = +2, $R_L$ = 75Ω, NTSC | 25°C | 0.05 | Degrees |
| Overdrive Recovery Time | $R_F$ = 510Ω, $V_{IN}$ = 5$V_{P-P}$ | 25°C | 7.5 | ns |

NOTE:

1. See Typical Performance Curves for more information.

## *Typical Performance Curves* $V_{SUPPLY} = \pm5V$, $R_F = 510\Omega$, $R_L = 100\Omega$, $T_A = 25^oC$, Unless Otherwise Specified

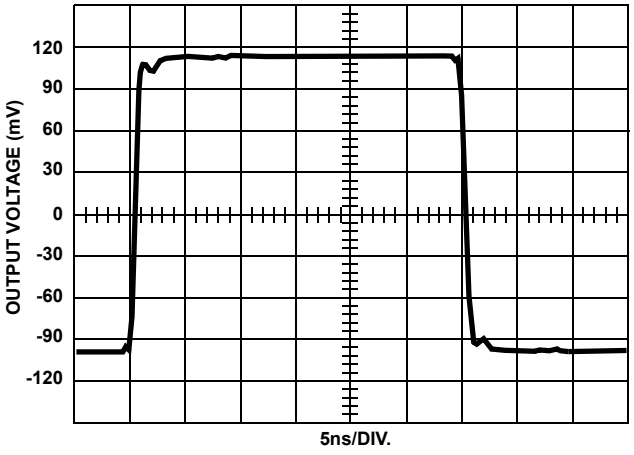



FIGURE 3. SMALL SIGNAL PULSE RESPONSE ($A_V = +2$)

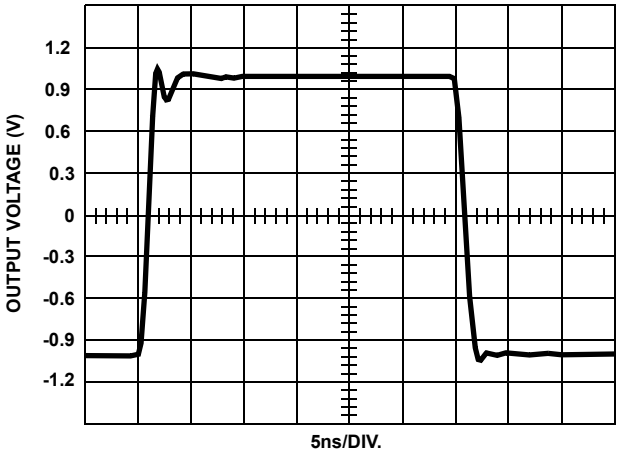



FIGURE 4. LARGE SIGNAL PULSE RESPONSE ($A_V = +2$)

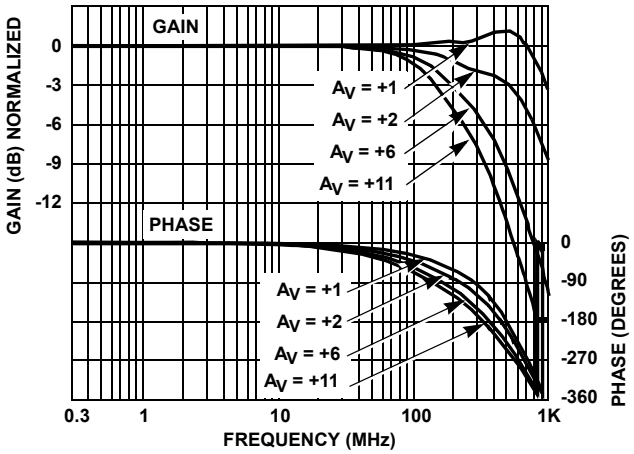



FIGURE 5. NON-INVERTING FREQUENCY RESPONSE ($V_{OUT} = 200mV_{P-P}$)

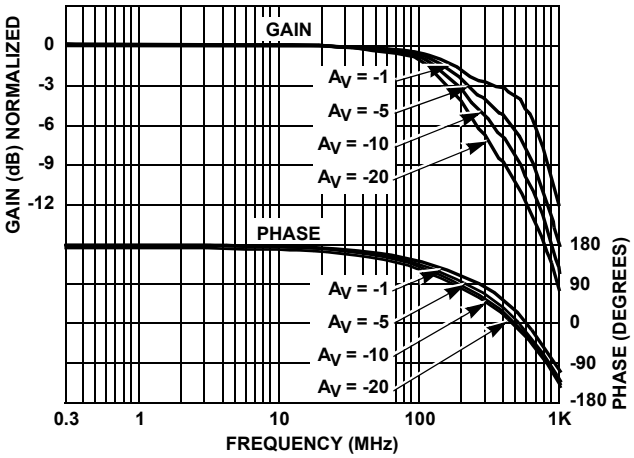



FIGURE 6. INVERTING FREQUENCY RESPONSE ($V_{OUT} = 200mV_{P-P}$)

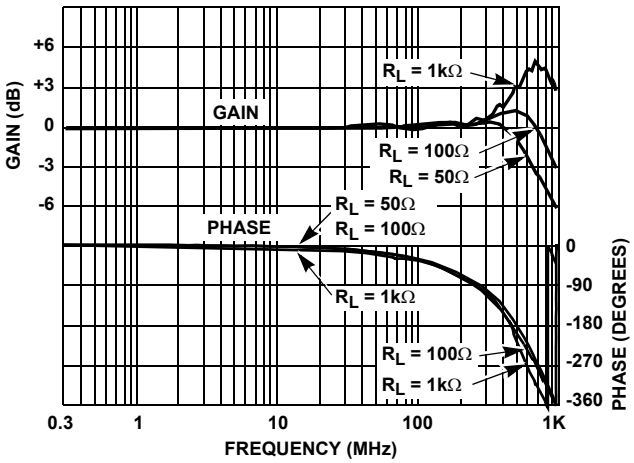



FIGURE 7. FREQUENCY RESPONSE FOR VARIOUS LOAD RESISTORS ($A_V = +1$, $V_{OUT} = 200mV_{P-P}$)

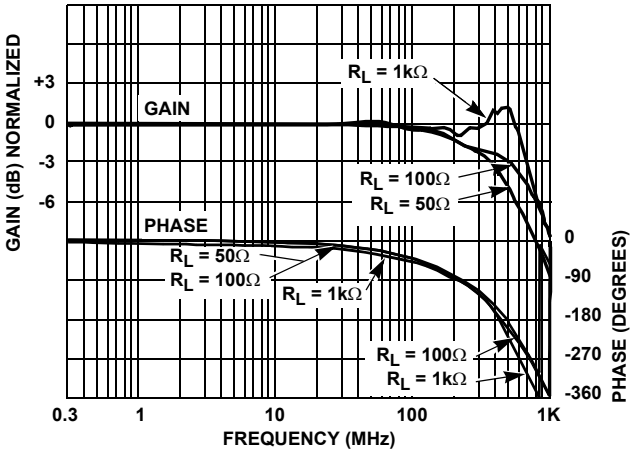



FIGURE 8. FREQUENCY RESPONSE FOR VARIOUS LOAD RESISTORS ($A_V = +2$, $V_{OUT} = 200mV_{P-P}$)

## *Typical Performance Curves* $V_{SUPPLY} = \pm5V$, $R_F = 510\Omega$, $R_L = 100\Omega$, $T_A = 25^oC$, Unless Otherwise Specified **(Continued)**

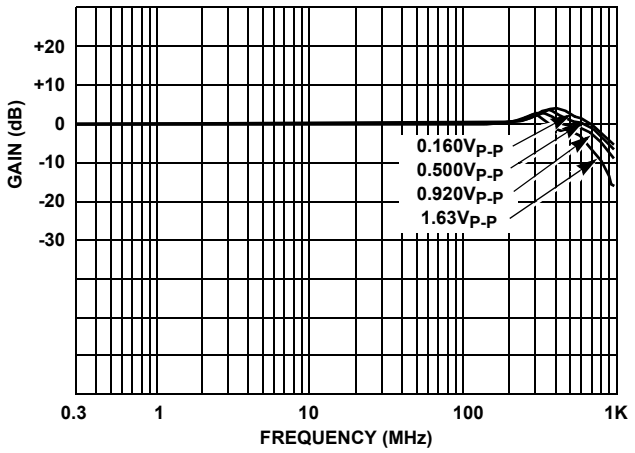



**FIGURE 9. FREQUENCY RESPONSE FOR VARIOUS OUTPUT VOLTAGES ($A_V$ = +1)**

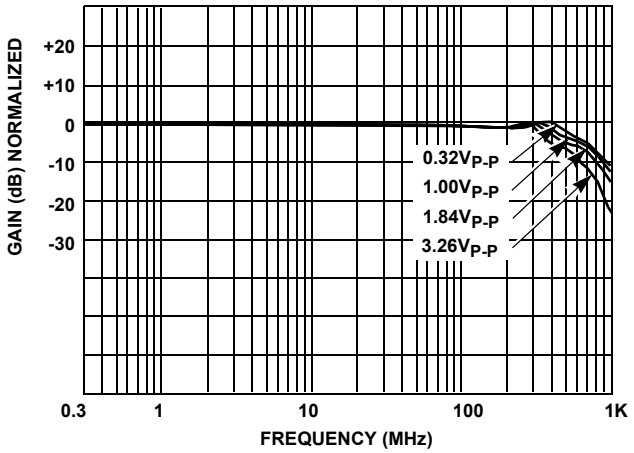



**FIGURE 10. FREQUENCY RESPONSE FOR VARIOUS OUTPUT VOLTAGES ($A_V$ = +2)**

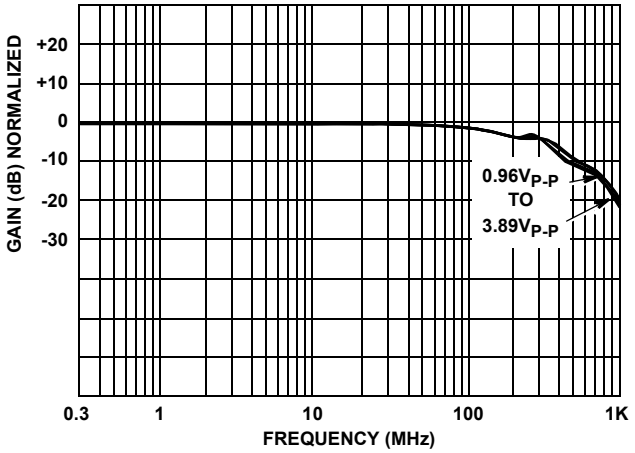



**FIGURE 11. FREQUENCY RESPONSE FOR VARIOUS OUTPUT VOLTAGES ($A_V$ = +6)**

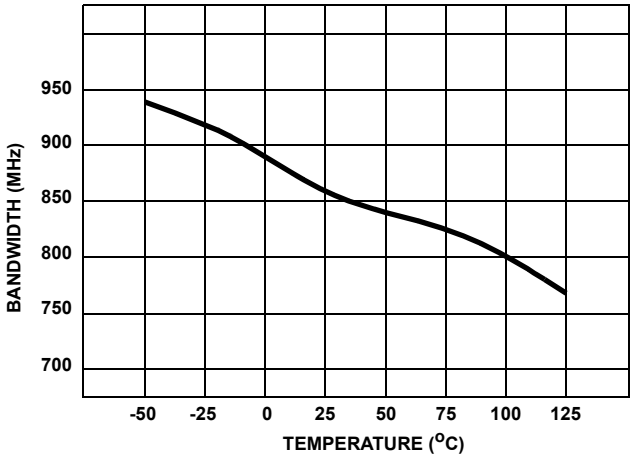



**FIGURE 12. -3dB BANDWIDTH vs TEMPERATURE ($A_V$ = +1)**

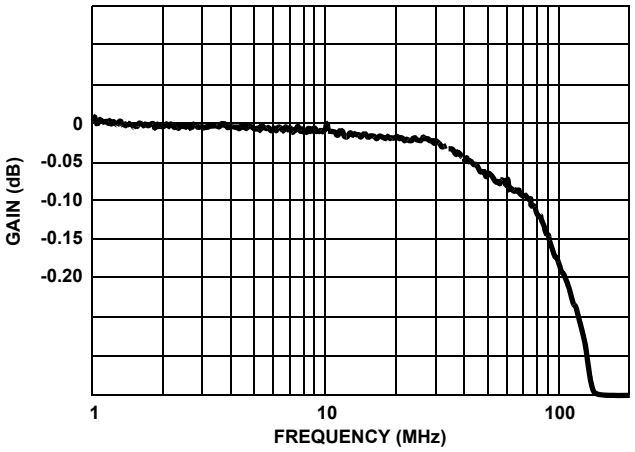



**FIGURE 13. GAIN FLATNESS ($A_V$ = +2)**

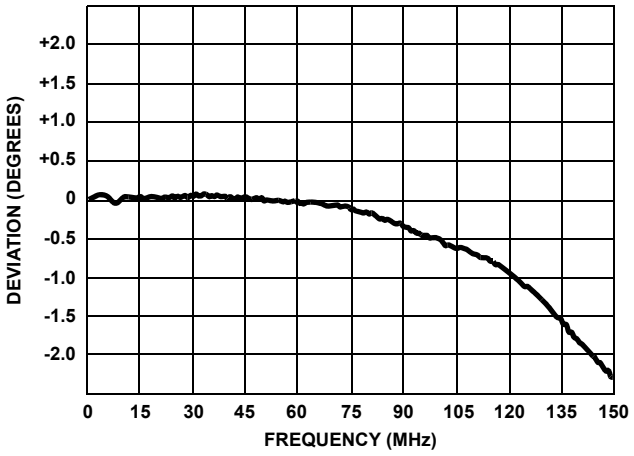



**FIGURE 14. DEVIATION FROM LINEAR PHASE ($A_V$ = +2)**

## *Typical Performance Curves* $V_{SUPPLY} = \pm5V$, $R_F = 510\Omega$, $R_L = 100\Omega$, $T_A = 25^oC$, Unless Otherwise Specified **(Continued)**

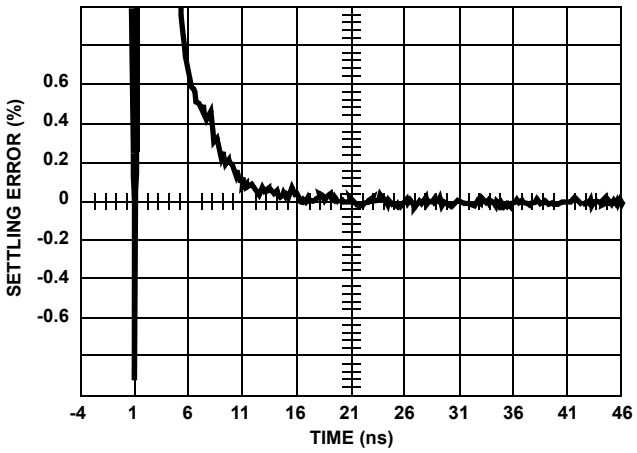



FIGURE 15. SETTLING RESPONSE ($A_V = +2$, $V_{OUT} = 2V$)

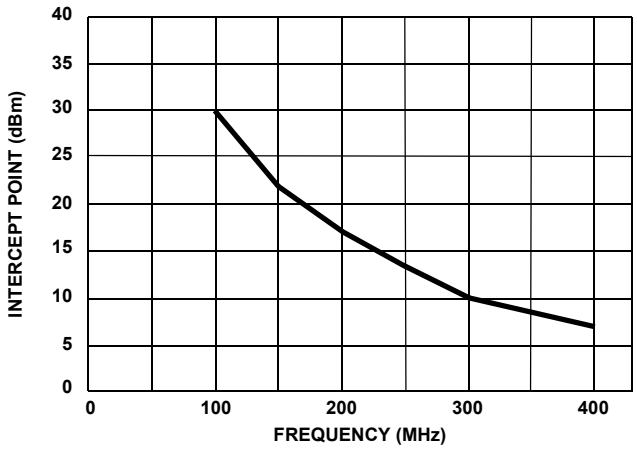



FIGURE 16. 3RD ORDER INTERMODULATION INTERCEPT (2-TONE)

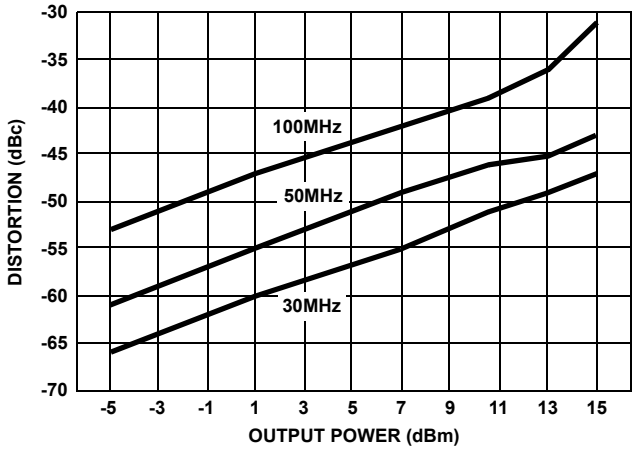



FIGURE 17. 2ND HARMONIC DISTORTION vs $P_{OUT}$

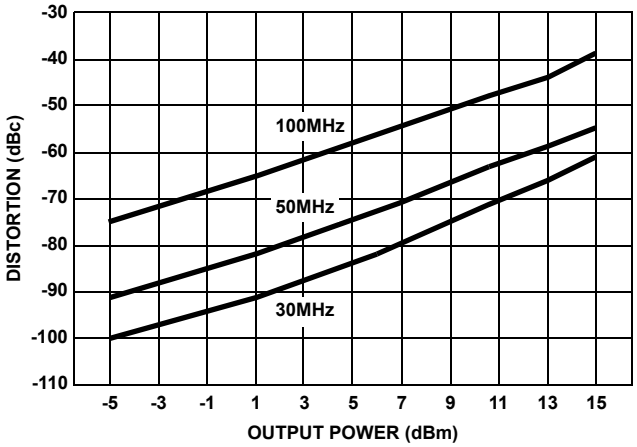



FIGURE 18. 3RD HARMONIC DISTORTION vs $P_{OUT}$

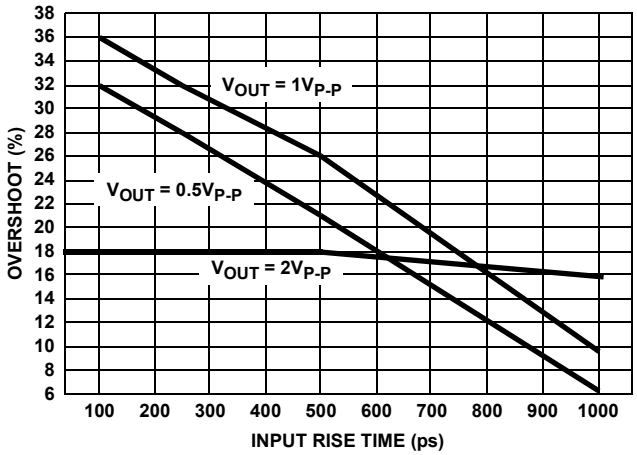



FIGURE 19. OVERSHOOT vs INPUT RISE TIME ($A_V = +1$)

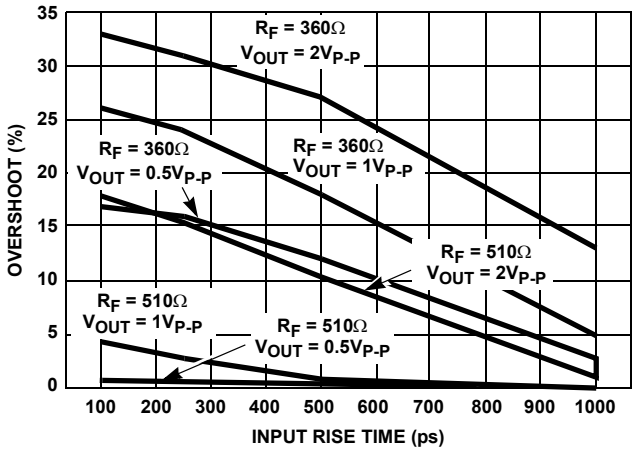



FIGURE 20. OVERSHOOT vs INPUT RISE TIME ($A_V = +2$)

## *Typical Performance Curves* $V_{SUPPLY} = \pm5V$, $R_F = 510\Omega$, $R_L = 100\Omega$, $T_A = 25^oC$, Unless Otherwise Specified **(Continued)**

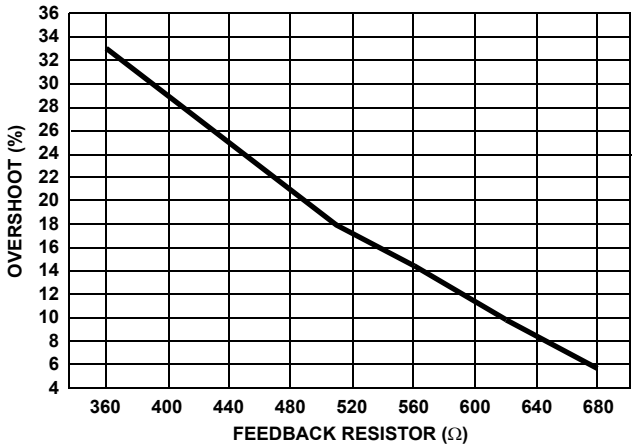



**FIGURE 21. OVERSHOOT vs FEEDBACK RESISTOR ($A_V$ = +2, $t_R$ = 200ps, $V_{OUT}$ = $2V_{P-P}$)**

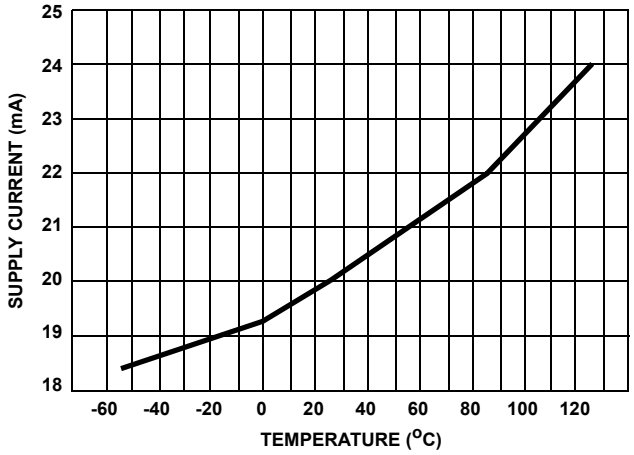



**FIGURE 22. SUPPLY CURRENT vs TEMPERATURE**

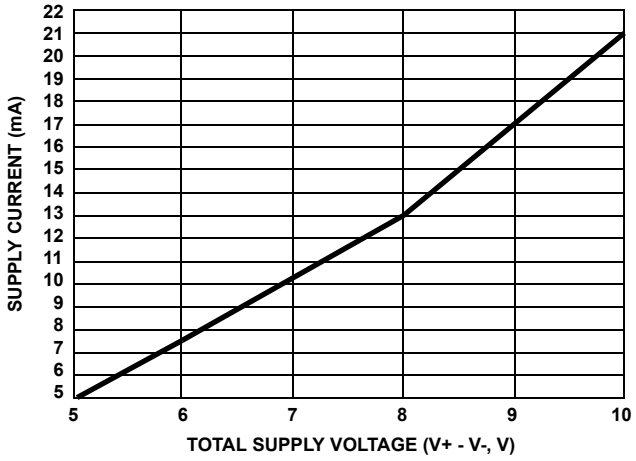



**FIGURE 23. SUPPLY CURRENT vs SUPPLY VOLTAGE**

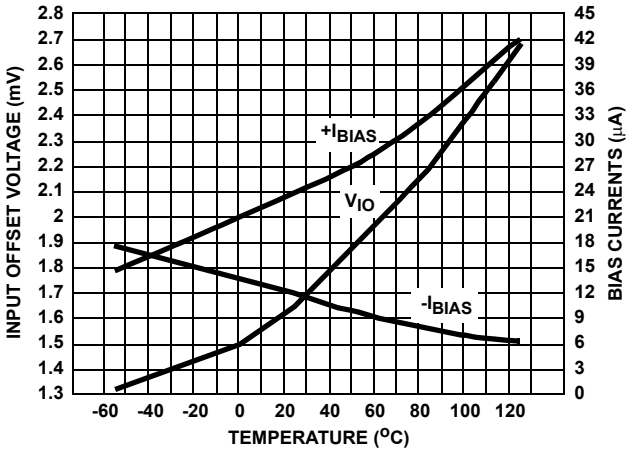



**FIGURE 24. $V_{IO}$ AND BIAS CURRENTS vs TEMPERATURE**

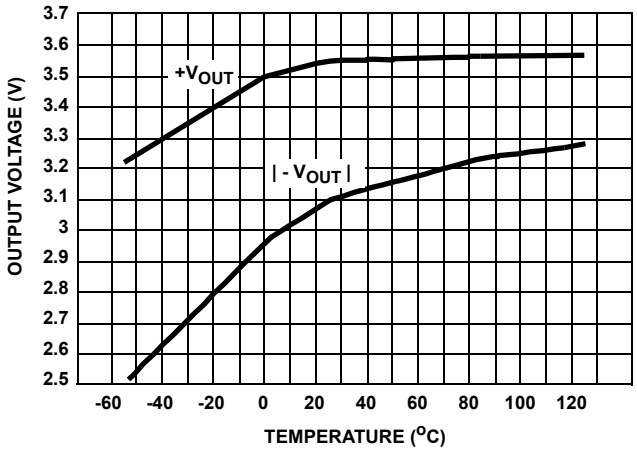



**FIGURE 25. OUTPUT VOLTAGE vs TEMPERATURE ($A_V$ = -1, $R_L$ = 50Ω)**

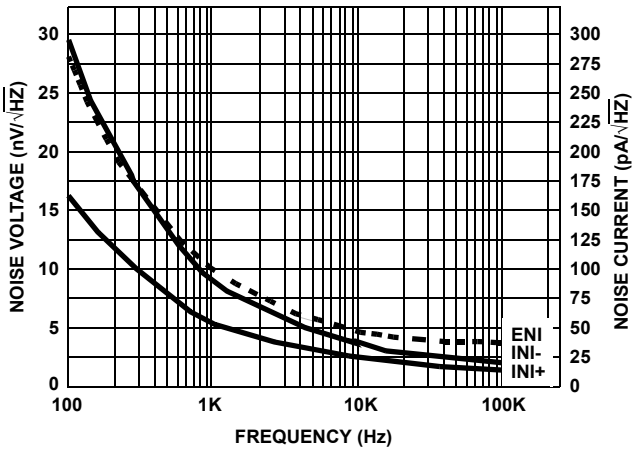
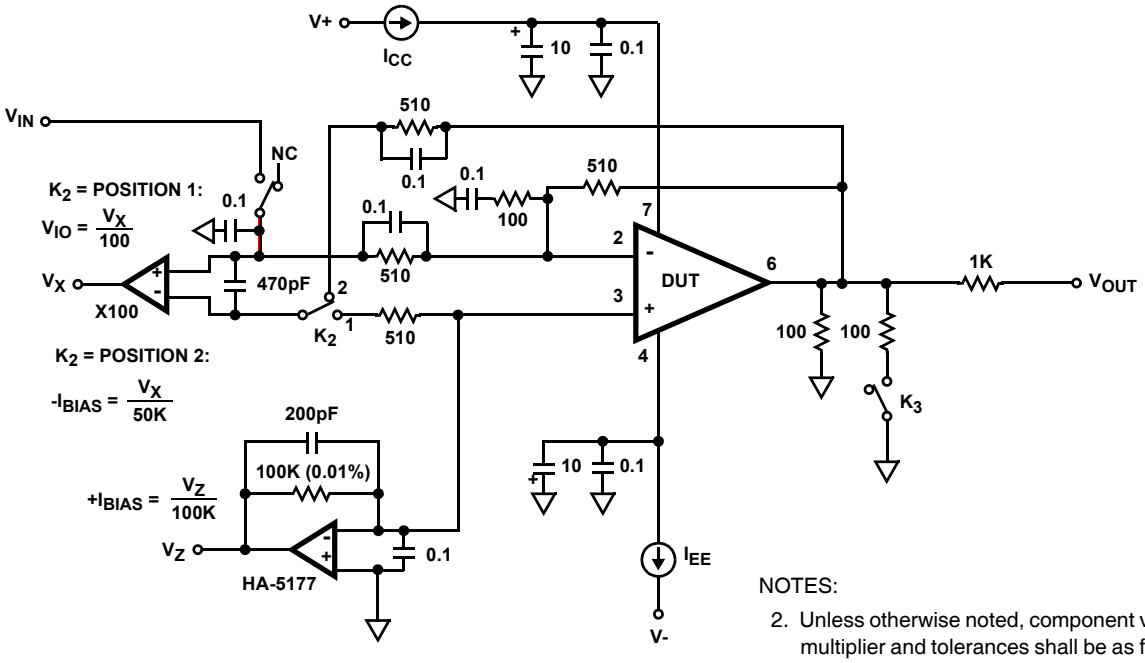



**FIGURE 26. INPUT NOISE vs FREQUENCY**

## Test Circuit

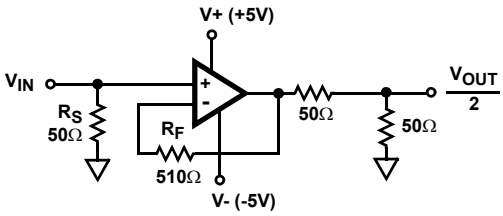



NOTES:

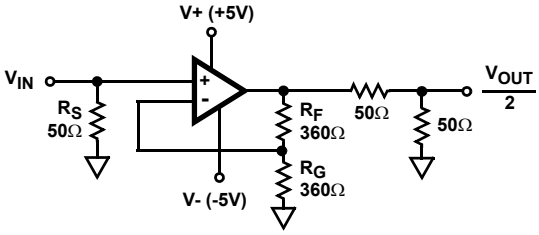
2. Unless otherwise noted, component value multiplier and tolerances shall be as follows:
   Resistors, Ω ±1%.
   Capacitors, μF ±10%
3. Chip Components Recommended.

## Test Waveforms

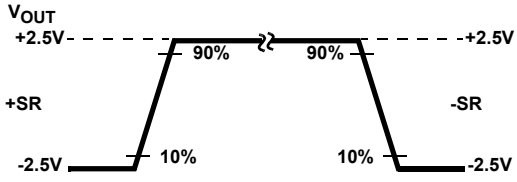
**SIMPLIFIED TEST CIRCUIT FOR LARGE AND SMALL SIGNAL PULSE RESPONSE**



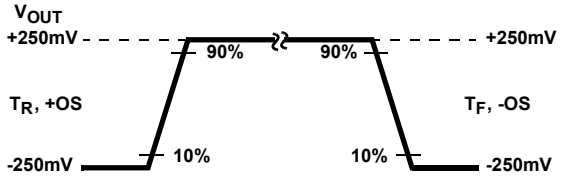

**$A_V$ = +1 TEST CIRCUIT**




**$A_V$ = +2 TEST CIRCUIT**



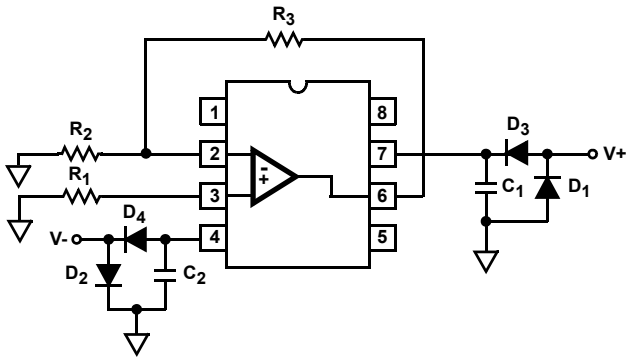

**LARGE SIGNAL WAVEFORM**




**SMALL SIGNAL WAVEFORM**

## Burn-In Circuit

HS-1100RH CERDIP

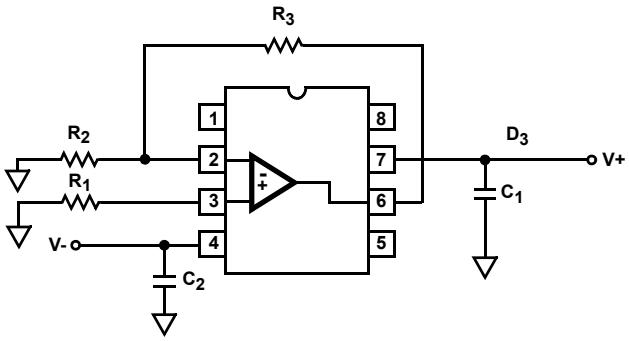



NOTES:

4. $R_1 = R_2 = 1k\Omega, \pm 5\%$ (Per Socket).
5. $R_3 = 10k\Omega, \pm 5\%$ (Per Socket).
6. $C_1 = C_2 = 0.01\mu F$ (Per Socket) or $0.1\mu F$ (Per Row) Min.
7. $D_1 = D_2 = 1N4002$ or Equivalent (Per Board).
8. $D_3 = D_4 = 1N4002$ or Equivalent (Per Socket).
9. V+ = +5.5V ±0.5V.
10. V- = -5.5V ±0.5V.

## Irradiation Circuit

HS-1100RH CERDIP




NOTES:

11. $R_1 = R_2 = 1k\Omega, \pm 5\%$.
12. $R_3 = 10k\Omega, \pm 5\%$.
13. $C_1 = C_2 = 0.1\mu F$.
14. V+ = +5.5V ± 0.5V.
15. V- = -5.5V ± 0.5V.

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## Die Characteristics

**DIE DIMENSIONS:**

63 mils x 44 mils x 19 mils ±1 mil
(1600µm x 1130µm x 483µm ±25.4µm)

**INTERFACE MATERIALS:**

**Glassivation:**

Type: Nitride
Thickness: 4kÅ ±0.5kÅ

**Top Metallization:**

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

**Substrate:**

UHF-1, Bonded Wafer, DI

**ASSEMBLY RELATED INFORMATION:**

**Substrate Potential (Powered Up):**

Floating

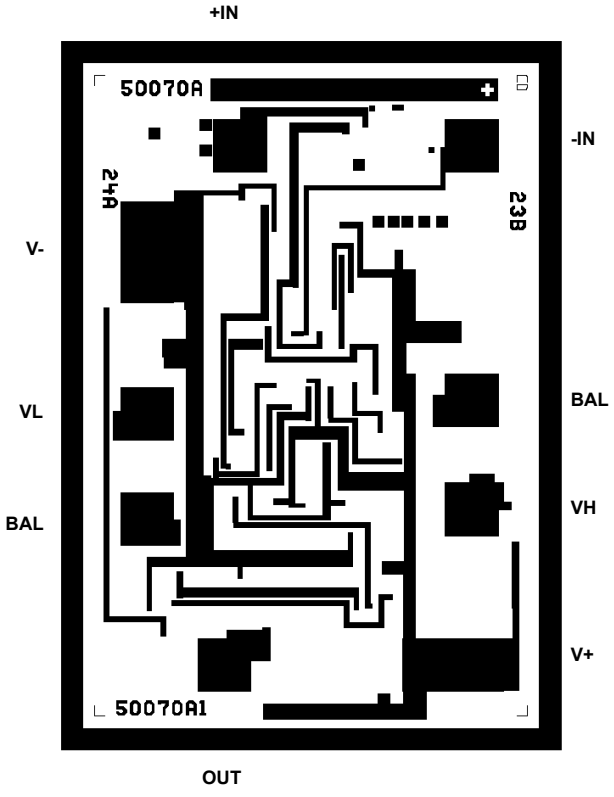
**ADDITIONAL INFORMATION:**

**Worst Case Current Density:**

$1.6 \times 10^5$ A/cm$^2$

**Transistor Count:**

52

## Metallization Mask Layout

**HS-1100RH**