# Ultralow Noise Precision High Speed Op Amps

## DESCRIPTION

The RH1028(gain of –1 stable)/RH1128(gain of +1 stable) achieve a new standard of excellence in noise performance with 0.9nV/√Hz 1kHz noise, 1.0nV/√Hz 10Hz noise. This ultralow noise is combined with excellent high speed specifications (gain-bandwidth product is 75MHz for RH1028, 20MHz for RH1128), distortion-free output, and true precision parameters (0.25µV/°C drift, 20µV offset voltage, 25 million voltage gain). Although the RH1028/RH1128 input stage operates at nearly 1mA of collector current to achieve low voltage noise, input bias current is only 50nA.

The RH1028/RH1128's voltage noise is less than the noise of a 50Ω resistor. Therefore, even in very low source impedance transducer or audio amplifier applications, the RH1028/RH1128's contribution to total system noise will be negligible.

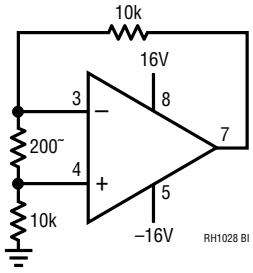
## ABSOLUTE MAXIMUM RATINGS

**(Note 1)**

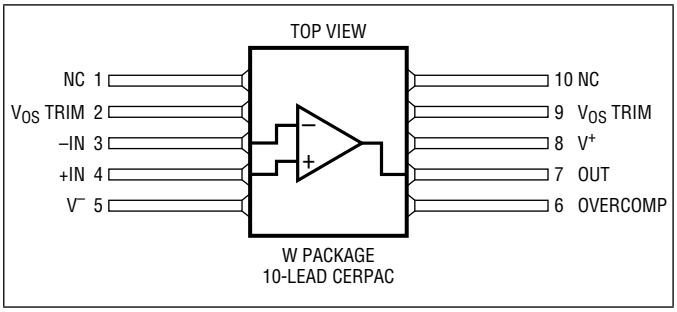
Supply Voltage (–55°C to 125°C).....±16V
Differential Input Current (Note 9) .....±25mA
Input Voltage.....Equal to Supply Voltage
Output Short-Circuit Duration ..... Indefinite
Operating Temperature Range..... –55°C to 125°C
Storage Temperature Range..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

All registered trademarks and trademarks are the property of their respective owners.

## BURN-IN CIRCUIT




## PACKAGE INFORMATION




## TABLE 1: ELECTRICAL CHARACTERISTICS

**(Preirradiation) $V_S$ = ±15V, $V_{CM}$ = 0V, unless otherwise noted.**

| SYMBOL | PARAMETER | CONDTIONS | NOTES | $T_A$ = 25°C MIN | $T_A$ = 25°C TYP | $T_A$ = 25°C MAX | SUB-GROUP | –55°C ≤ $T_A$ ≤ 125°C MIN | –55°C ≤ $T_A$ ≤ 125°C TYP | –55°C ≤ $T_A$ ≤ 125°C MAX | SUB-GROUP | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | | 2 | | 20 | 80 | 1 | | 45 | 180 | 2, 3 | µV |
| $\frac{\Delta V_{OS}}{\Delta Time}$ | Long-Term Input Offset Voltage Stability | | 3 | | 0.3 | | | | | | | µV/$M_O$ |
| $\frac{\Delta V_{OS}}{\Delta Temp}$ | Average Input Offset Voltage Drift | | 8 | | | | | | 0.25 | 1.0 | | µV/°C |
| $I_{OS}$ | Input Offset Current | $V_{CM}$ = 0V | | | 18 | 150 | 1 | | 30 | 200 | 2, 3 | nA |
| $I_B$ | Input Bias Current | $V_{CM}$ = 0V | | | ±50 | ±400 | 1 | | ±100 | ±600 | 2, 3 | nA |
| $e_n$ | Input Noise Voltage Density | $f_O$ = 10Hz<br>$f_O$ = 1000Hz, 100% Tested | 5 | | 1.0<br>0.9 | 2.5<br>1.6 | | | | | | nV/√Hz<br>nV/√Hz |

Rev. F

# TABLE 1: ELECTRICAL CHARACTERISTICS

**(Preirradiation) $V_S$ = ±15V, $V_{CM}$ = 0V, unless otherwise noted.**

| SYMBOL | PARAMETER | CONDTIONS | NOTES | $T_A$ = 25°C MIN | $T_A$ = 25°C TYP | $T_A$ = 25°C MAX | SUB-GROUP | –55°C ≤ $T_A$ ≤ 125°C MIN | –55°C ≤ $T_A$ ≤ 125°C TYP | –55°C ≤ $T_A$ ≤ 125°C MAX | SUB-GROUP | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $I_n$ | Input Noise Current Density | $f_O$ = 10Hz<br>$f_O$ = 1000Hz, 100% Tested | 4, 6 | | 4.7<br>1.0 | 24<br>3.6 | | | | | | pA/√Hz<br>pA/√Hz |
| | Input Resistance<br>Common Mode<br>Differential Mode | | | | <br>300<br>20 | | | | | | | <br>MΩ<br>kΩ |
| | Input Capacitance | | | | 5 | | | | | | | pF |
| | Input Voltage Range | | | ±11.0 | ±12.2 | | | ±10.3 | ±11.7 | | | V |
| CMRR | Common Mode Rejection Ratio | $V_{CM}$ = ±11V<br>$V_{CM}$ = ±10.3V | | 110 | 126 | | 1 | <br>100 | <br>120 | | 2, 3 | dB |
| PSRR | Power Supply Rejection Ratio | $V_S$ = ±4V to ±18V<br>$V_S$ = ±4.5V to ±16V | | 110 | 132 | | 1 | <br>104 | <br>130 | | 2, 3 | dB |
| $A_{VOL}$ | Large-Scale Voltage Gain | $R_L$ ≥ 2k, $V_O$ = ±10V<br>$R_L$ ≥ 1k, $V_O$ = ±10V<br>$R_L$ ≥ 600Ω, $V_O$ = ±10V | | 5.0<br>3.5<br>2.0 | 25<br>20<br>15 | | 4 | 2.0<br>1.5 | 14<br>10 | | 5, 6 | V/µV<br>V/µV<br>V/µV |
| $V_{OUT}$ | Maximum Output Voltage Swing | $R_L$ ≥ 2k<br>$R_L$ ≥ 600Ω | | ±12.0<br>±10.5 | ±13.0<br>±12.2 | | 4 | ±10.3 | ±11.6 | | 5, 6 | V<br>V |
| SR | Slew Rate | $A_{VCL}$ = –1 (RH1028)<br>$A_{VCL}$ = –1 (RH1128) | | 11.0<br>4.5 | 15<br>6 | | 4 | | | | | V/µs<br>V/µs |
| GWB | Gain Bandwidth Product | $f_O$ = 20kHz (RH1028)<br>$f_O$ = 200kHz (RH1128) | 7<br>7 | 50<br>11 | 75<br>20 | | | | | | | MHz<br>MHz |
| $Z_O$ | Open-Loop Output Impedance | $V_O$ = 0, $I_O$ = 0 | | | 80 | | | | | | | Ω |
| $I_S$ | Supply Current | | | | 7.6 | 10.5 | 1 | | 9 | 13 | 2, 3 | mA |

# TABLE 1A: ELECTRICAL CHARACTERISTICS

**(Postirradiation) $V_S$ = ±15V, $V_{CM}$ = 0V, $T_A$ = 25°C, unless otherwise noted.**

| SYMBOL | PARAMETER | CONDTIONS | NOTES | 10KRAD(Si) MIN | 10KRAD(Si) MAX | 20KRAD(Si) MIN | 20KRAD(Si) MAX | 50KRAD(Si) MIN | 50KRAD(Si) MAX | 100KRAD(Si) MIN | 100KRAD(Si) MAX | 200KRAD(Si) MIN | 200KRAD(Si) MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | | 2 | | 100 | | 120 | | 140 | | 160 | | 180 | µV |
| $I_{OS}$ | Input Offset Current | | | | 200 | | 200 | | 200 | | 300 | | 500 | nA |
| $I_B$ | Input Bias Current | | | | ±600 | | ±700 | | ±950 | | ±1100 | | ±1700 | nA |
| SR | Slew Rate | $A_{VCL}$ = –1 (RH1028)<br>$A_{VCL}$ = –1 (RH1128) | | 7.5<br>3.0 | | 7.5<br>3.0 | | 7.5<br>3.0 | | 7.5<br>3.0 | | 7.5<br>3.0 | | V/µs<br>V/µs |
| | Input Voltage Range | | | ±11 | | ±11 | | ±11 | | ±11 | | ±11 | | V |
| CMRR | Common Mode Rejection Ratio | $V_{CM}$ = ±11V | | 106 | | 106 | | 106 | | 106 | | 106 | | dB |
| PSRR | Power Supply Rejection Ratio | $V_S$ = ±4V to ±18V | | 104 | | 104 | | 104 | | 104 | | 104 | | dB |
| $A_{VOL}$ | Large-Signal Voltage Gain | $R_L \geq 2k$, $V_O$ = ±10V | | 2 | | 2 | | 2 | | 2 | | 2 | | V/µV |
| $V_{OUT}$ | Maximum Output Voltage Swing | $R_L \geq 2k$<br>$R_L \geq 600\Omega$ | | ±11.5<br>±10 | | ±11.5<br>±10 | | ±11.5<br>±10 | | ±11.5<br>±10 | | ±11.5<br>±10 | | V<br>V |

**Note 1:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

**Note 2:** Input offset voltage measurements are performed by automatic test equipment approximately 0.5 seconds after application of power. In addition, at $T_A$ = 25°C, offset voltage is measured with the chip heated to approximately 55°C to account for the chip temperature rise when the device is fully warmed up.

**Note 3:** Long-term input offset voltage stability refers to the average trend line of Offset Voltage vs Time over extended periods after the first 30 days of operation. Excluding the initial hour of operation, changes in $V_{OS}$ during the first 30 days are typically 2.5µV.

**Note 4:** This parameter is tested on a sample basis only.

**Note 5:** 10Hz noise voltage density is sample tested on every lot. Devices 100% tested at 10Hz are available on request.

**Note 6:** Current noise is defined and measured with balanced source resistors. The resultant voltage noise (after subtracting the resistor noise on an RMS basis) is divided by the sum of the two source resistors to obtain current noise. Maximum 10Hz current noise can be inferred from 100% testing at 1kHz.

**Note 7:** Gain-bandwidth product is not tested. It is guaranteed by design and by inference from the slew rate measurement.

**Note 8:** This parameter is not 100% tested.

**Note 9:** The inputs are protected by back-to-back diodes. Current-limiting resistors are not used in order to achieve low noise. If differential input voltage exceeds ±1.8V, the input current should be limited to 25mA.

# TABLE 2: ELECTRICAL TEST REQUIREMENTS

| MIL-PRF-38535 TEST REQUIREMENTS | SUBGROUP |
|---|---|
| Final Electrical Test Requirements | 1*, 2, 3, 4 |
| Group A Test Requirements | 1, 2, 3, 4 |
| Group C End Point Electrical Parameters** | 1, 2, 3, 4 |
| Group D End Point Electrical Parameters | 1, 2, 3, 4 |
| Group E End Point Electrical Parameters | 1 |

*PDA Applies to subgroup 1. See PDA Test Notes.
**Post Group C 25°C Limits are as follows:

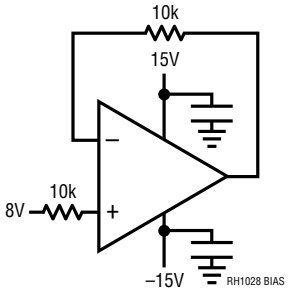
| | SUBGROUP 1 | SUBGROUP 2, 3 | UNITS |
|---|---|---|---|
| $V_{OS}$ | ±240 | ±340 | µV |
| $I_{OS}$ | ±350 | ±400 | nA |
| $I_B$ | ±760 | ±960 | nA |

**PDA Test Notes**

The PDA is specified as 5% based on failures from group A, subgroup 1, tests after cooldown as the final electrical test in accordance with method 5004 of MIL-STD-883 Class B. The verified failures (including Delta parameters) of group A, subgroup 1, after burn-in divided by the total number of devices submitted for burn-in in that lot shall be used to determine the percent for the lot.

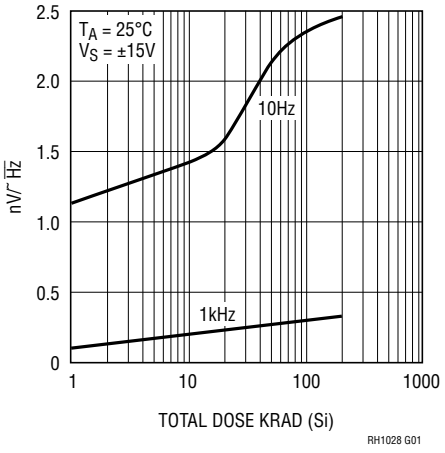
Analog Devices, Inc., reserves the right to test to tighter limits than those given.

# TOTAL DOSE BIAS CIRCUIT

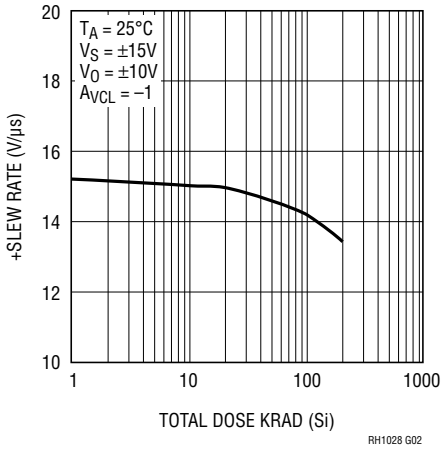



# TYPICAL PERFORMANCE CHARACTERISTICS

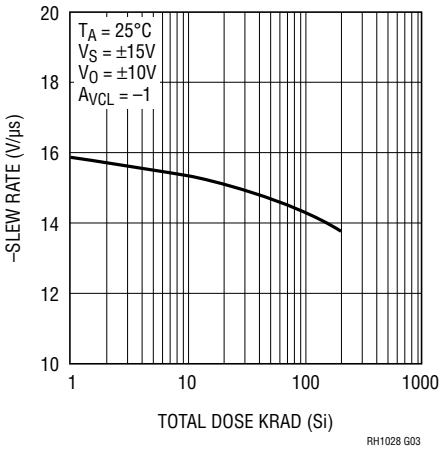
**Noise Voltage Density**




**RH1028 Positive Slew Rate**



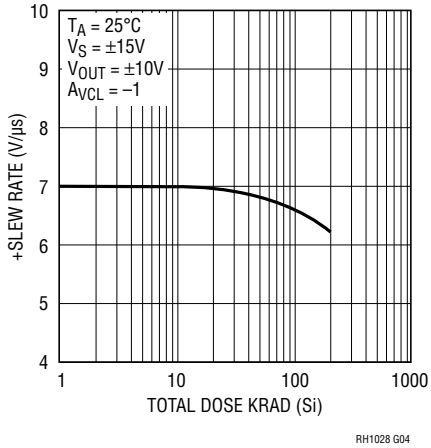

**RH1028 Negative Slew Rate**



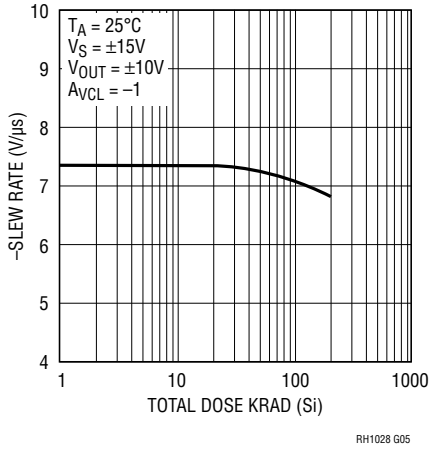

Rev. F

# TYPICAL PERFORMANCE CHARACTERISTICS

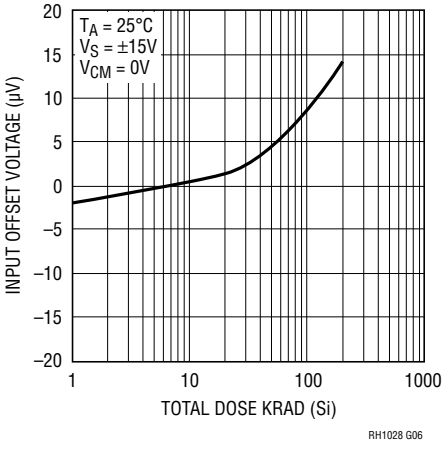
### RH1128 Positive Slew Rate



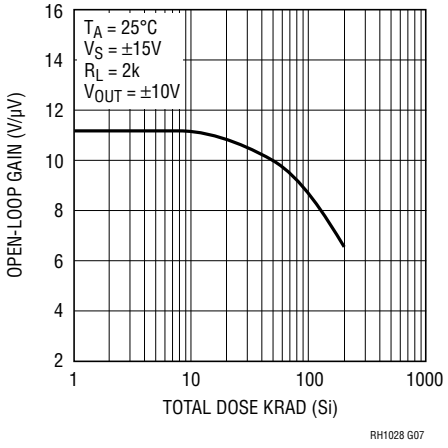

### RH1128 Negative Slew Rate



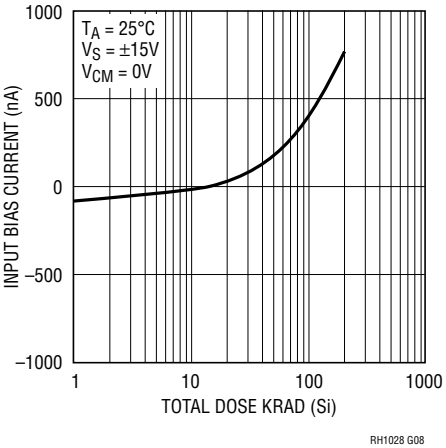

### Input Offset Voltage



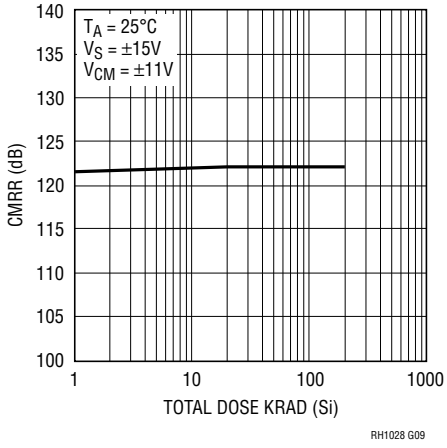

### Open-Loop Gain



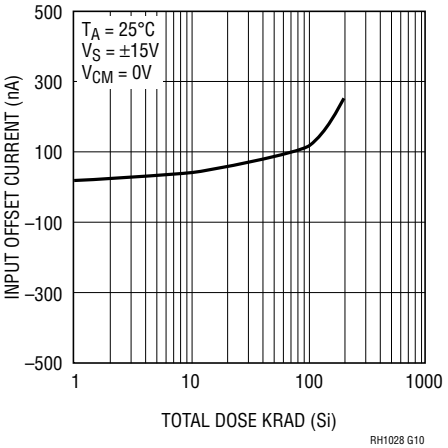

### Input Bias Current



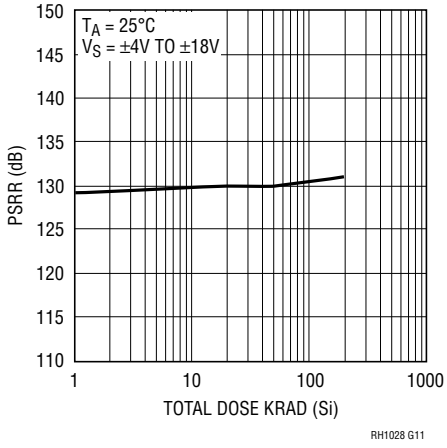

### Common Mode Rejection Ratio



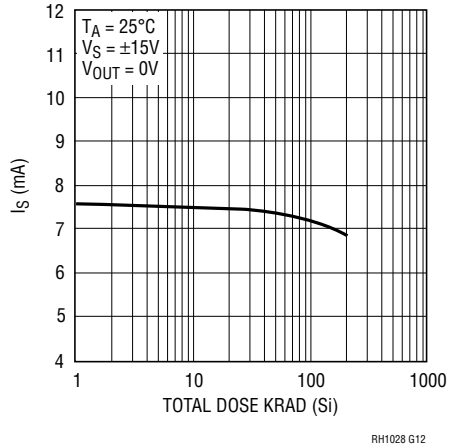

### Input Offset Current




### Power Supply Rejection Ratio




### Supply Current






Information furnished by Analog Devices is believed to be accurate and reliable. However, no responsibility is assumed by Analog Devices for its use, nor for any infringements of patents or other rights of third parties that may result from its use. Specifications subject to change without notice. No license is granted by implication or other. For more information www.analog.comwise under any patent or patent rights of Analog Devices.

## REVISION HISTORY (Revision history begins at Rev E)

| REV | DATE | DESCRIPTION | PAGE NUMBER |
|---|---|---|---|
| E | 04/15 | Updated postirradiation 20/500/100/200k Rad Input Bias Current Specification | 2 |
| F | 07/24 | Updated Table 2: Electrical Test Requirements | 4 |


© ANALOG DEVICES, INC. 2024