

**Low Noise, High Speed  
Rail-to-Rail Op Amp**

**DESCRIPTION**

The RH6200 is an ultralow noise, rail-to-rail input and output unity-gain stable op amp that features 0.95nV/ $\sqrt{\text{Hz}}$  noise voltage. This amplifier combines very low noise with a 165MHz gain bandwidth, 50V/ $\mu\text{s}$  slew rate and is optimized for low voltage signal conditioning systems. A shutdown pin reduces supply current during standby conditions and thermal shutdown protects the part from overload conditions. The RH6200 maintains its pre-irradiation performance for supplies from 4.5V to 12.6V and is specified pre- and post-radiation at 5V and  $\pm 5\text{V}$ .

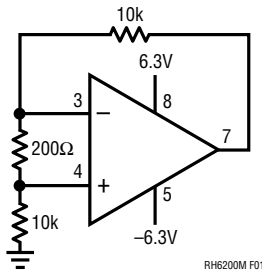
**ABSOLUTE MAXIMUM RATINGS**

(Note 1)

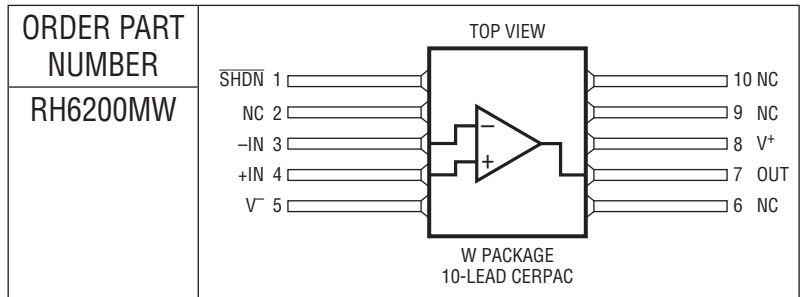
Total Supply Voltage ( $V^+$ to $V^-$ ).....	12.6V
Input Current (Note 2).....	$\pm 40\text{mA}$
Output Short-Circuit Duration (Note 3) .....	Indefinite
Pin Current While Exceeding Supplies (Note 4) ...	$\pm 30\text{mA}$
Operating Junction Temperature Range (Note 5) .....	$-55^\circ\text{C}$ to $125^\circ\text{C}$
Storage Temperature Range .....	$-65^\circ\text{C}$ to $150^\circ\text{C}$
Lead Temperature (Soldering, 10 sec).....	$300^\circ\text{C}$

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**BURN-IN CIRCUIT**



**PACKAGE/ORDER INFORMATION**



**TABLE 1: ELECTRICAL CHARACTERISTICS (Preirradiation)**

Device is characterized at the TID levels below. Device is production tested at 100kRad(si).

SYMBOL	PARAMETER	CONDITIONS	NOTES	$T_A = 25^\circ\text{C}$			SUB-GROUP	$-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$			SUB-GROUP	UNITS
				MIN	TYP	MAX		MIN	TYP	MAX		
$V_{OS}$	Input Offset Voltage	$V_S = 5\text{V}, 0\text{V}; V_{CM} = V^- \text{ to } V^+$ $V_S = \pm 5\text{V}; V_{CM} = V^- \text{ to } V^+$			0.6	2	1		4	2,3	mV	
					2.5	6	1		9	2,3	mV	
$I_B$	Input Bias Current	$V_S = 5\text{V}, 0\text{V}; V_{CM} = V^+$ $V_S = 5\text{V}, 0\text{V}; V_{CM} = V^-$ $V_S = \pm 5\text{V}; V_{CM} = V^+$ $V_S = \pm 5\text{V}; V_{CM} = V^-$			8	18	1		20	2,3	$\mu\text{A}$	
				-50	-23	1	-100	2,3	$\mu\text{A}$			
					8	18	1		20	2,3	$\mu\text{A}$	
				-50	-23	1	-200	2,3	$\mu\text{A}$			
$I_{OS}$	Input Offset Current	$V_S = 5\text{V}, 0\text{V}; V_{CM} = V^+$ $V_S = 5\text{V}, 0\text{V}; V_{CM} = V^-$ $V_S = \pm 5\text{V}; V_{CM} = V^+$ $V_S = \pm 5\text{V}; V_{CM} = V^-$			0.02	4	1		5	2,3	$\mu\text{A}$	
					0.4	5	1		25	2,3	$\mu\text{A}$	
					1	7	1		12	2,3	$\mu\text{A}$	
					3	12	1		50	2,3	$\mu\text{A}$	

**TABLE 1: ELECTRICAL CHARACTERISTICS** (Preirradiation)

Device is characterized at the TID levels below. Device is production tested at 100kRad(si).

SYMBOL	PARAMETER	CONDITIONS	NOTES	T <sub>A</sub> = 25°C			SUB-GROUP	-55°C ≤ T <sub>A</sub> ≤ 125°C			SUB-GROUP	UNITS
				MIN	TYP	MAX		MIN	TYP	MAX		
	Input Noise Voltage	0.1Hz to 10Hz	6		600							nV <sub>p-p</sub>
e <sub>n</sub>	Input Noise Voltage Density	V <sub>S</sub> = 5V, 0V; f = 100kHz	6		1.1							nV/√Hz
		V <sub>S</sub> = 5V, 0V; f = 10kHz			1.5	2.4						nV/√Hz
		V <sub>S</sub> = ±5V; f = 100kHz	6		0.95							nV/√Hz
		V <sub>S</sub> = ±5V; f = 10kHz			1.4	2.3						nV/√Hz
i <sub>n</sub>	Input Noise Current Density	f = 10kHz Balanced Source	6		2.2							pA/√Hz
		f = 10kHz Unbalanced Source	6		3.5							pA/√Hz
A <sub>VOL</sub>	Large Signal Open-Loop Voltage Gain	V <sub>S</sub> = 5V, 0V; R <sub>L</sub> = 1k; V <sub>OUT</sub> = 0.5V to 4.5V		70	120		4	35		5,6		V/mV
		V <sub>S</sub> = 5V, 0V; R <sub>L</sub> = 100Ω; V <sub>OUT</sub> = 1V to 4V		11	18		4					V/mV
		V <sub>S</sub> = 5V, 0V; R <sub>L</sub> = 100Ω; V <sub>OUT</sub> = 1.5V to 3.5V						5.5		5,6		V/mV
		V <sub>S</sub> = ±5V; R <sub>L</sub> = 1k; V <sub>OUT</sub> = ±4.5V		115	200		4	40		5,6		V/mV
		V <sub>S</sub> = ±5V; R <sub>L</sub> = 100Ω; V <sub>OUT</sub> = ±2V		15	26		4	7		5,6		V/mV
CMRR	Common Mode Rejection Ratio	V <sub>S</sub> = 5V, 0V; V <sub>CM</sub> = 0V to 5V		65	90		1	58		2,3		dB
		V <sub>S</sub> = 5V, 0V; V <sub>CM</sub> = 1.5V to 3.5V		85	112		1	76		2,3		dB
		V <sub>S</sub> = ±5V; V <sub>CM</sub> = ±5V		68	96		1	63		2,3		dB
		V <sub>S</sub> = ±5V; V <sub>CM</sub> = ±2V		75	100		1	72		2,3		dB
PSRR	Power Supply Rejection Ratio	V <sub>S</sub> = ±2.25V to ±5V		60	68		1	58		2,3		dB
V <sub>OL</sub>	Output Voltage Swing Low	V <sub>S</sub> = 5V, 0V; I <sub>L</sub> = 0			9	50	4			100	5,6	mV
		V <sub>S</sub> = 5V, 0V; I <sub>L</sub> = 5mA			50	100	4			150	5,6	mV
		V <sub>S</sub> = 5V, 0V; I <sub>L</sub> = 20mA			150	290	4			350	5,6	mV
		V <sub>S</sub> = ±5V; I <sub>L</sub> = 0			12	50	4			100	5,6	mV
		V <sub>S</sub> = ±5V; I <sub>L</sub> = 5mA			55	110	4			150	5,6	mV
		V <sub>S</sub> = ±5V; I <sub>L</sub> = 20mA			150	290	4			350	5,6	mV
V <sub>OH</sub>	Output Voltage Swing High	V <sub>S</sub> = 5V, 0V; I <sub>L</sub> = 0			55	110	4			150	5,6	mV
		V <sub>S</sub> = 5V, 0V; I <sub>L</sub> = 5mA			95	190	4			250	5,6	mV
		V <sub>S</sub> = 5V, 0V; I <sub>L</sub> = 20mA			220	400	4			500	5,6	mV
		V <sub>S</sub> = ±5V; I <sub>L</sub> = 0			70	130	4			200	5,6	mV
		V <sub>S</sub> = ±5V; I <sub>L</sub> = 5mA			110	210	4			275	5,6	mV
		V <sub>S</sub> = ±5V; I <sub>L</sub> = 20mA			225	420	4			550	5,6	mV
I <sub>SC</sub>	Short-Circuit Current	V <sub>S</sub> = 5V, 0V or V <sub>S</sub> = ±5V		±60	±90		1	±45		2,3		mA
I <sub>S</sub>	Supply Current	V <sub>S</sub> = 5V, 0V			16.5	20	1			30	2,3	mA
		V <sub>S</sub> = ±5V			20	23	1			35	2,3	mA
I <sub>S(SHDN)</sub>	Shutdown Supply Current	V <sub>S</sub> = 5V, 0V			1.3	1.8	1			2.2	2,3	mA
		V <sub>S</sub> = ±5V			1.6	2.1	1			2.5	2,3	mA
I <sub>SHDN</sub>	Shutdown Pin Current	V <sub>S</sub> = 5V, 0V or V <sub>S</sub> = ±5V; V <sub>SHDN</sub> = 0.3V		-280	-200		1	-300		2,3		μA
t <sub>ON</sub>	Turn-On Time	SHDN from Low to High	6		180							ns
t <sub>OFF</sub>	Turn-On Time	SHDN from High to Low	6		180							ns
GBW	Gain Bandwidth Product	V <sub>S</sub> = 5V, 0V; at f = 1MHz V <sub>S</sub> = ±5V; at f = 1MHz	6		110	145						MHz
SR	Slew Rate	V <sub>S</sub> = 5V, 0V; A <sub>V</sub> = -1; R <sub>L</sub> = 1k; V <sub>O</sub> = 4V		31	44		4					V/μs
		V <sub>S</sub> = ±5V; A <sub>V</sub> = -1; R <sub>L</sub> = 1k; V <sub>O</sub> = 4V		35	50		4					V/μs

**TABLE 1A: ELECTRICAL CHARACTERISTICS** (Postirradiation)  $T_A = 25^\circ\text{C}$ 

Device is characterized at the TID levels below. Device is production tested at 100kRad(Si).

SYMBOL	PARAMETER	CONDITIONS	10KRAD(Si)		20KRAD(Si)		50KRAD(Si)		100KRAD(Si)		200KRAD(Si)		UNITS
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{OS}$	Input Offset Voltage	$V_S = 5V, 0V; V_{CM} = V^- \text{ to } V^+$		2.2		2.4		2.6		2.8		3	mV
		$V_S = \pm 5V; V_{CM} = V^- \text{ to } V^+$		6.5		7		7.5		8		8.5	mV
$I_B$	Input Bias Current	$V_S = 5V, 0V; V_{CM} = V^+$		20		22		24		26		28	$\mu\text{A}$
		$V_S = 5V, 0V; V_{CM} = V^-$	-55		-60		-65		-70		-75		$\mu\text{A}$
		$V_S = \pm 5V; V_{CM} = V^+$		20		22		24		26		28	$\mu\text{A}$
		$V_S = \pm 5V; V_{CM} = V^-$	-55		-60		-65		-70		-75		$\mu\text{A}$
$I_{OS}$	Input Offset Current	$V_S = 5V, 0V; V_{CM} = V^+$		5		6		7		8		9	$\mu\text{A}$
		$V_S = 5V, 0V; V_{CM} = V^-$		6		7		8		9		10	$\mu\text{A}$
		$V_S = \pm 5V; V_{CM} = V^+$		8		9		10		11		12	$\mu\text{A}$
		$V_S = \pm 5V; V_{CM} = V^-$		13		14		15		16		17	$\mu\text{A}$
$A_{VOL}$	Large Signal Open Loop Voltage Gain	$V_S = 5V, 0V; R_L = 1k; V_{OUT} = 0.5V \text{ to } 4.5V$	65		60		55		50		45		V/mV
		$V_S = 5V, 0V; R_L = 100\Omega; V_{OUT} = 1V \text{ to } 4V$		10		9		8		7		6	V/mV
		$V_S = \pm 5V; R_L = 1k; V_{OUT} = \pm 4.5V$		110		100		90		80		70	V/mV
		$V_S = \pm 5V; R_L = 100\Omega; V_{OUT} = \pm 2V$		13.5		12		10.5		9		7.5	V/mV
CMRR	Common Mode Rejection Ratio	$V_S = 5V, 0V; V_{CM} = 0V \text{ to } 5V$		64		63		62		61		60	dB
		$V_S = 5V, 0V; V_{CM} = 1.5V \text{ to } 3.5V$		84		83		82		81		80	dB
		$V_S = \pm 5V; V_{CM} = \pm 5V$		67		66		65		64		63	dB
		$V_S = \pm 5V; V_{CM} = \pm 2V$		74		73		72		71		70	dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 2.25V \text{ to } \pm 5V$		59		58		57		56		55	dB
$V_{OL}$	Output Voltage Swing Low	$V_S = 5V, 0V; I_L = 0$		52		54		56		58		60	mV
		$V_S = 5V, 0V; I_L = 5mA$		104		108		112		116		120	mV
		$V_S = 5V, 0V; I_L = 20mA$		296		302		308		314		320	mV
		$V_S = \pm 5V; I_L = 0$		52		54		56		58		60	mV
		$V_S = \pm 5V; I_L = 5mA$		114		118		122		126		130	mV
		$V_S = \pm 5V; I_L = 20mA$		296		302		308		314		320	mV
$V_{OH}$	Output Voltage Swing High	$V_S = 5V, 0V; I_L = 0$		114		118		122		126		130	mV
		$V_S = 5V, 0V; I_L = 5mA$		198		206		214		222		230	mV
		$V_S = 5V, 0V; I_L = 20mA$		415		430		445		460		475	mV
		$V_S = \pm 5V; I_L = 0$		134		138		142		146		150	mV
		$V_S = \pm 5V; I_L = 5mA$		218		226		234		242		250	mV
		$V_S = \pm 5V; I_L = 20mA$		430		455		470		485		500	mV
$I_{SC}$	Short-Circuit Current	$V_S = 5V, 0V \text{ or } V_S = \pm 5V$		58		56		54		52		50	mA
$I_S$	Supply Current	$V_S = 5V, 0V$		20.4		20.8		21.2		21.6		22	mA
		$V_S = \pm 5V$		23.4		23.8		24.2		24.6		25	mA
$I_{S(SHDN)}$	Shutdown Supply Current	$V_S = 5V, 0V$		1.84		1.88		1.92		1.96		2	mA
		$V_S = \pm 5V$		2.14		2.18		2.22		2.26		2.3	mA
$I_{SHDN}$	Shutdown Pin Current	$V_S = 5V, 0V \text{ or } V_S = \pm 5V; V_{SHDN} = 0.3V$		-284		-288		-292		-296		-300	$\mu\text{A}$

**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:** Inputs are protected by back-to-back diodes. If the differential input voltage exceeds 0.7V, the input current must be limited to less than 40mA.

**Note 3:** A heat sink may be required to keep the junction temperature below the absolute maximum rating when the output is shorted indefinitely.

**Note 4:** There are reverse-biased ESD diodes from all inputs and outputs to the respective supply pins. If these pins are forced beyond either supply, unlimited current will flow through these diodes. If the current is transient in nature and limited to less than 30mA, no damage to the device will occur.

**Note 5:** The RH6200 is tested under pulse load conditions such that  $T_J \approx T_A$ . The thermal resistance of the W 10-lead CERPAC package (without heat sink) is estimated at 170°C/W. For a given application, multiply the RMS power dissipation of the RH6200 times the package thermal resistance (including any heat sinking if present) to calculate the temperature difference between the ambient temperature and the junction temperature. The RH6200 has a thermal shutdown feature that protects the part from excessive junction temperature. The amplifier will shut down to an inactive, low current condition when the junction temperature exceeds approximately 160°C. The amplifier will remain shut down until the die cools off to below approximately 150°C, at which point the amplifier will return to normal operation.

**Note 6:** This parameter is not production tested. Typical bench evaluation performance listed for information only.

## TABLE 2: ELECTRICAL TEST REQUIREMENTS

MIL-STD-883 TEST REQUIREMENTS	SUBGROUP
Final Electrical Test Requirements (Method 5004)	1*, 2, 3, 4, 5, 6
Group A Test Requirements (Method 5005)	1*, 2, 3, 4, 5, 6
Group B and D for Class S, End Point Electrical Parameters (Method 5005)	1, 2, 3

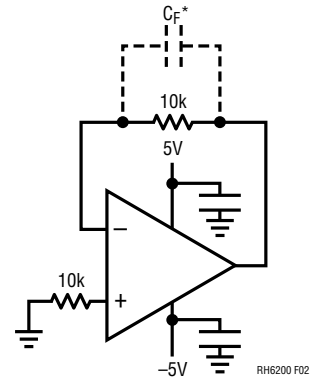
\*PDA applies to subgroup 1. See PDA Test Notes.

### 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. The verified failures 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.

Linear Technology Corporation reserves the right to test to tighter limits than those given.

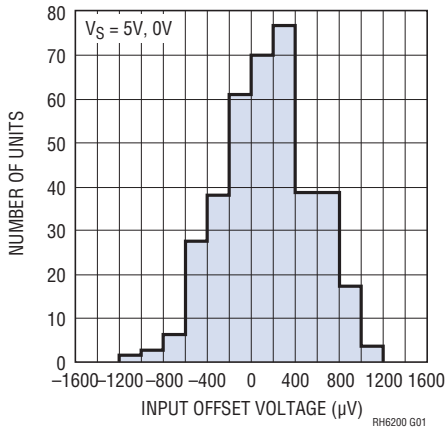
## TOTAL DOSE BIAS CIRCUIT



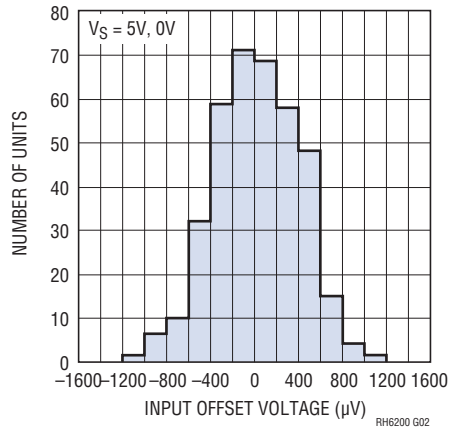
\*C<sub>F</sub> IS COMPONENT OR PARASITIC CAPACITANCE ENSURING STABILITY

## TYPICAL PERFORMANCE CHARACTERISTICS

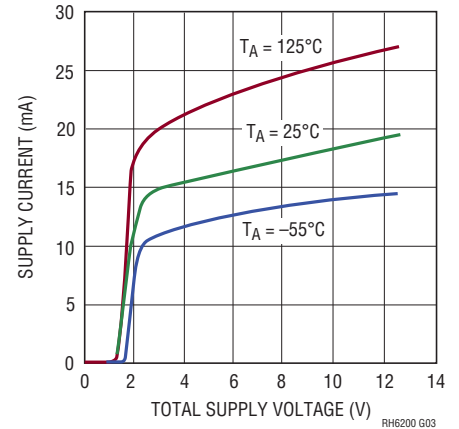
V<sub>OS</sub> Distribution, V<sub>CM</sub> = V<sup>+</sup>



V<sub>OS</sub> Distribution, V<sub>CM</sub> = V<sup>-</sup>

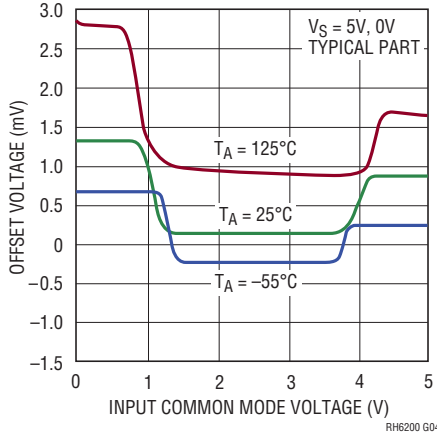


Supply Current vs Supply Voltage

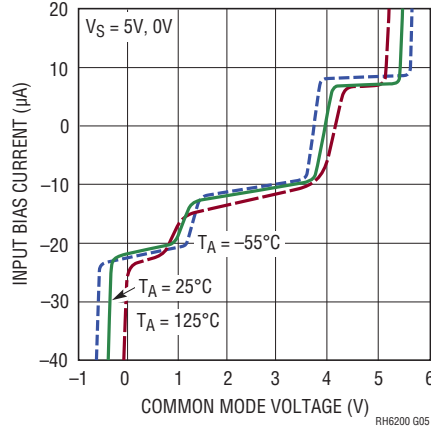


# TYPICAL PERFORMANCE CHARACTERISTICS

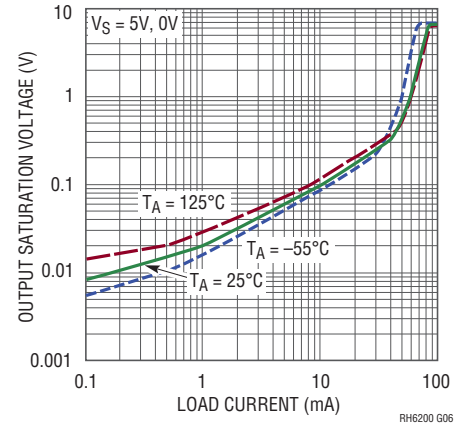
**Offset Voltage vs Input Common Mode Voltage**



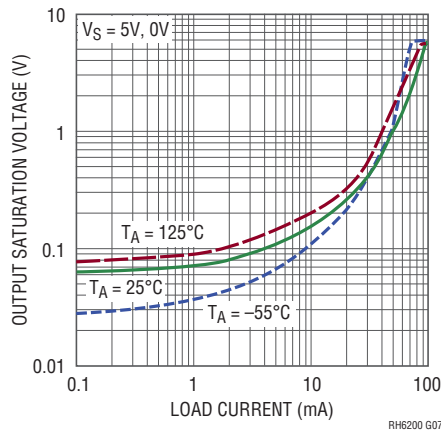
**Input Bias Current vs Common Mode Voltage**



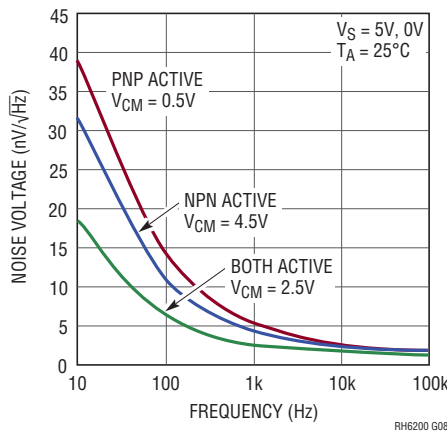
**Output Saturation Voltage vs Load Current (Output Low)**



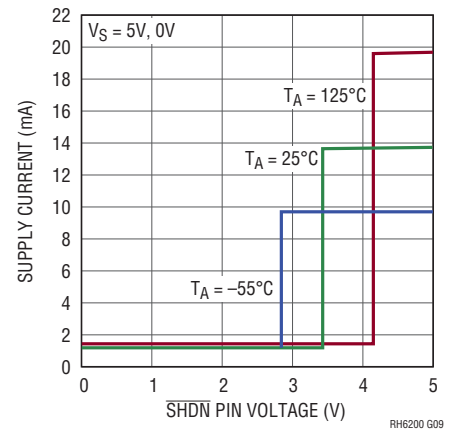
**Output Saturation Voltage vs Load Current (Output High)**



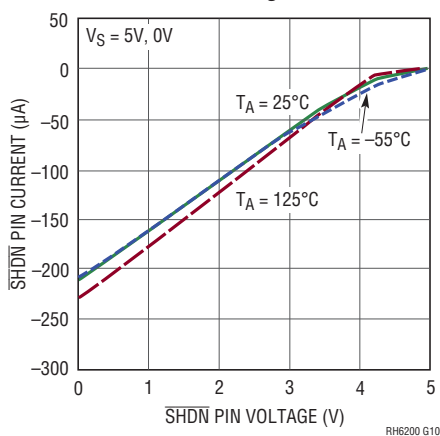
**Input Noise Voltage vs Frequency**



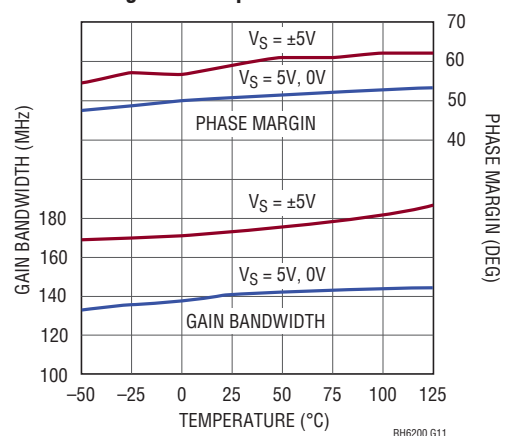
**Supply Current vs SHDN Pin Voltage**



**SHDN Pin Current vs SHDN Pin Voltage**

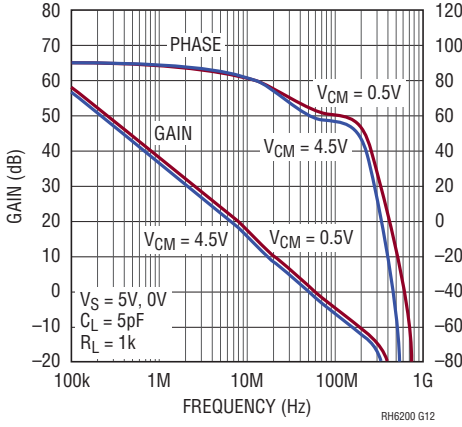


**Gain Bandwidth and Phase Margin vs Temperature**

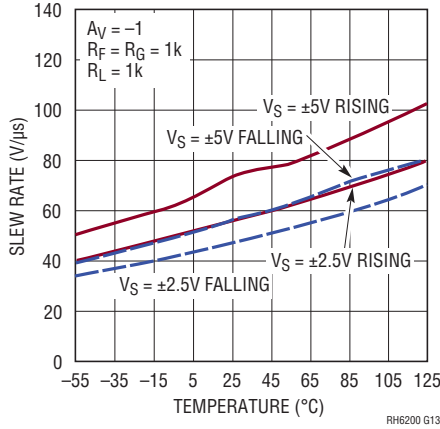


## TYPICAL PERFORMANCE CHARACTERISTICS

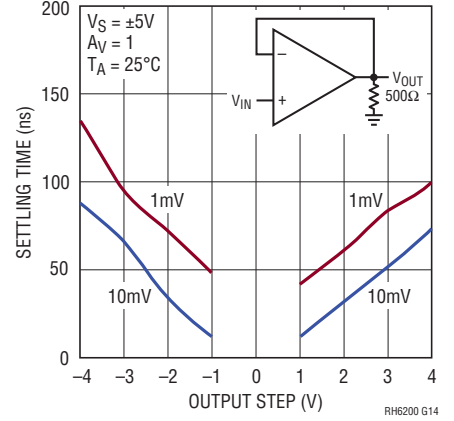
### Open-Loop Gain vs Frequency



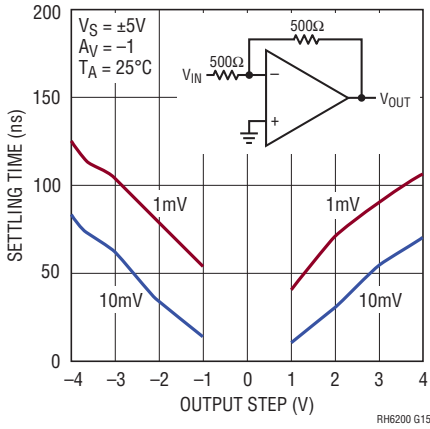
### Slew Rate vs Temperature



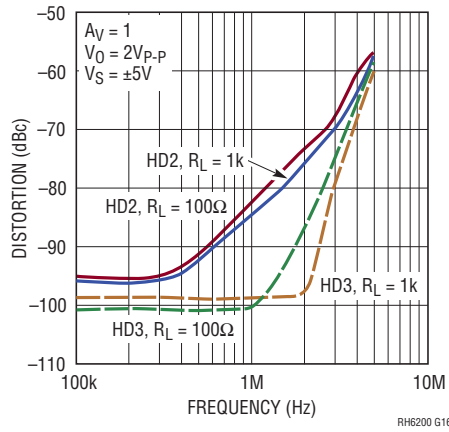
### Settling Time vs Output Step (Noninverting)



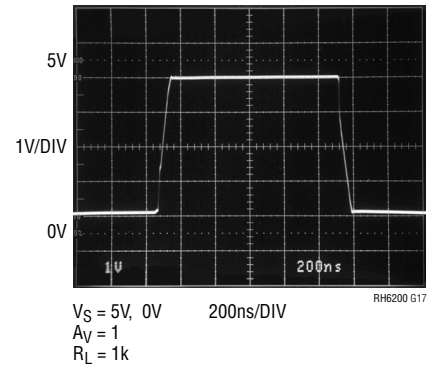
### Settling Time vs Output Step (Inverting)



### Distortion vs Frequency, $A_V = 1$

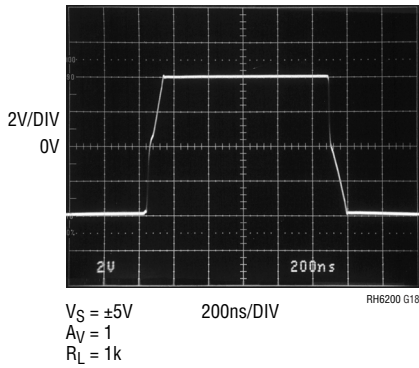


### 5V Large-Signal Response

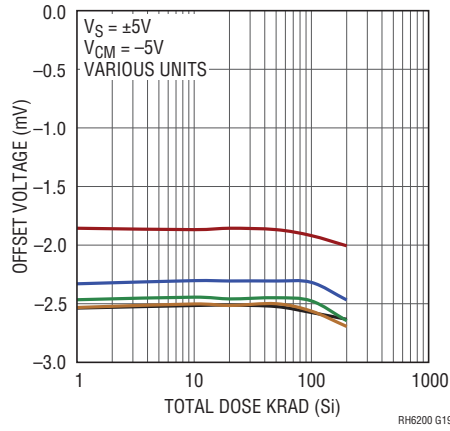


# TYPICAL PERFORMANCE CHARACTERISTICS

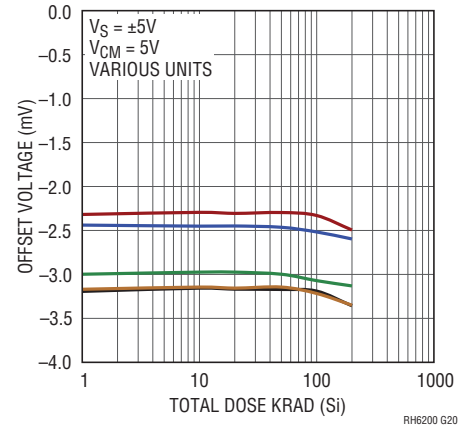
**±5V Large-Signal Response**



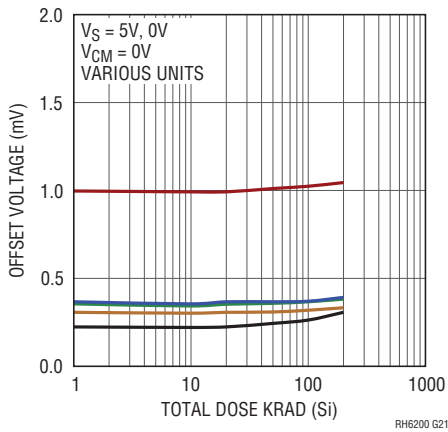
**Offset Voltage**



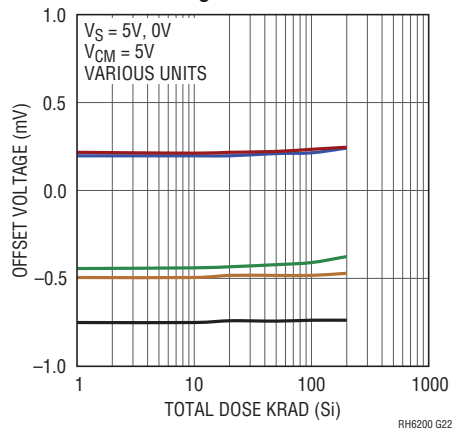
**Offset Voltage**



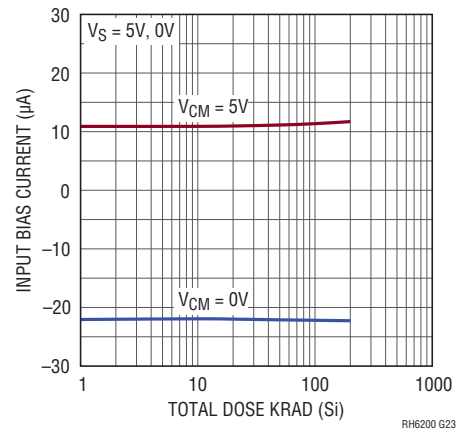
**Offset Voltage**



**Offset Voltage**

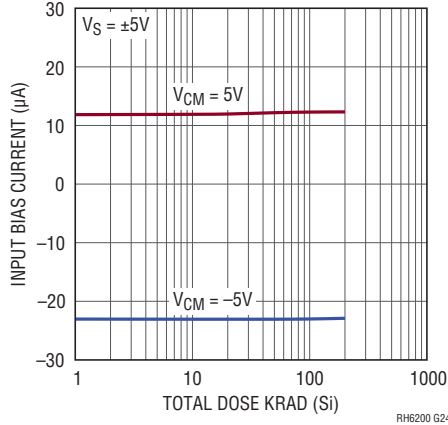


**Input Bias Current**

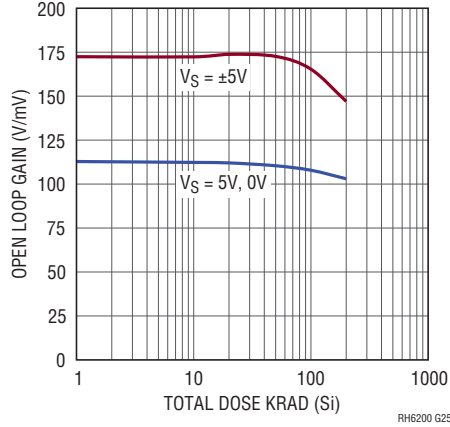


## TYPICAL PERFORMANCE CHARACTERISTICS

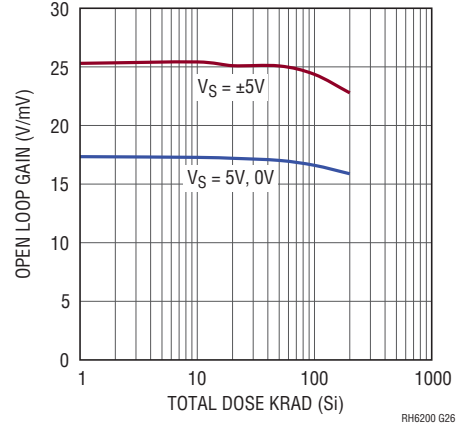
**Input Bias Current**



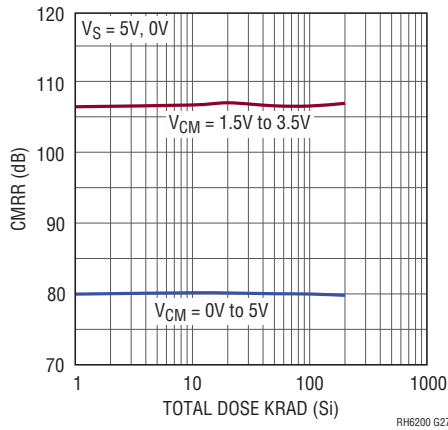
**Open-Loop Voltage Gain,  $R_L = 1k$**



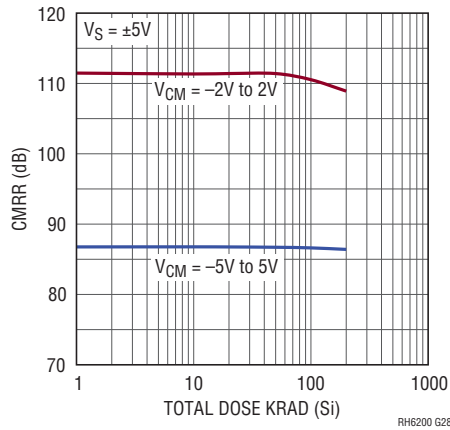
**Open-Loop Voltage Gain,  $R_L = 100\Omega$**



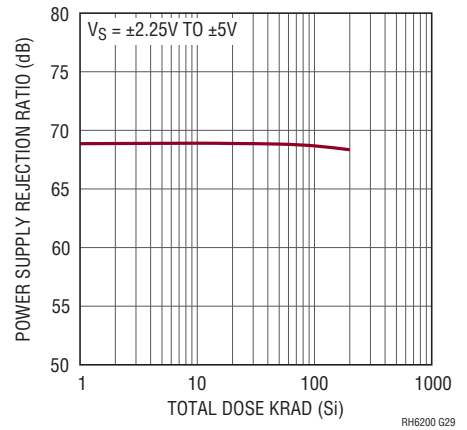
**Common Mode Rejection Ratio**



**Common Mode Rejection Ratio**



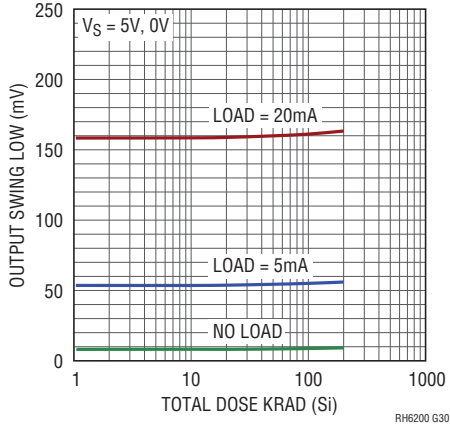
**Power Supply Rejection Ratio**





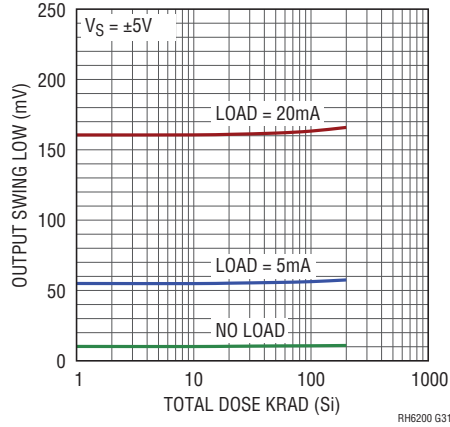
# TYPICAL PERFORMANCE CHARACTERISTICS

**Output Swing Low**



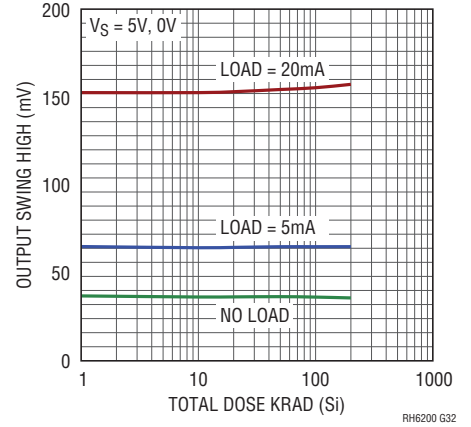
RH6200 G30

**Output Swing Low**



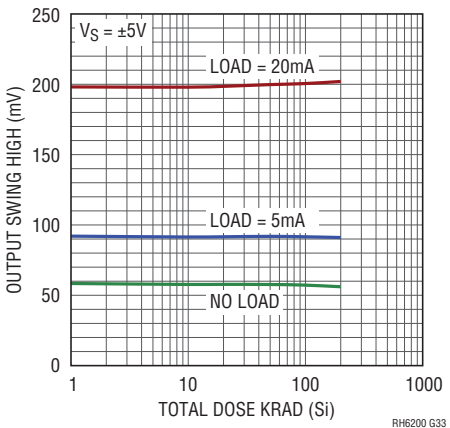
RH6200 G31

**Output Swing High**



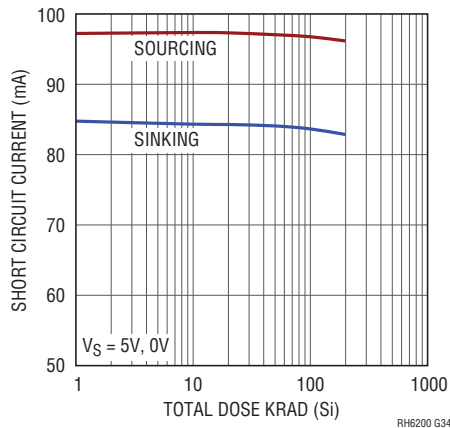
RH6200 G32

**Output Swing High**



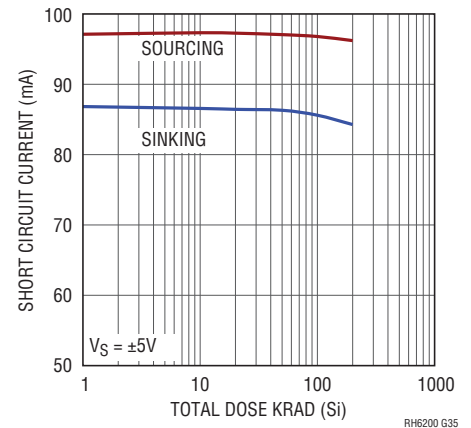
RH6200 G33

**Short-Circuit Current**



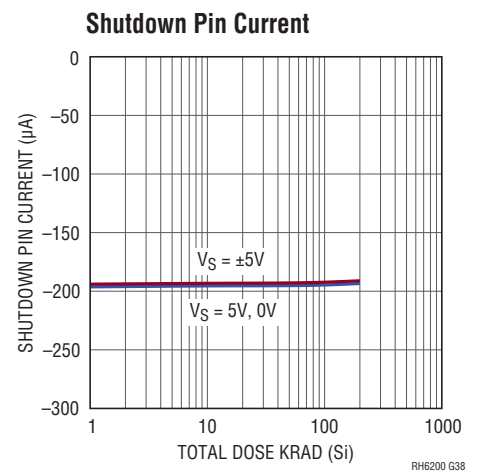
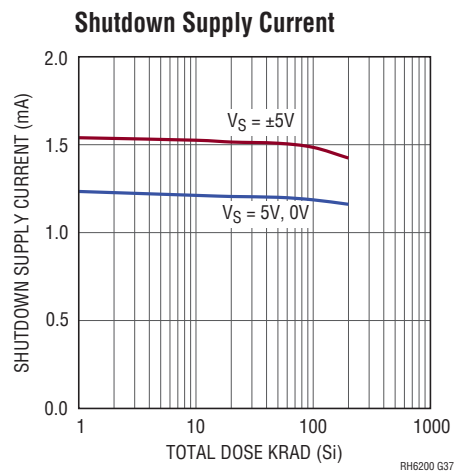
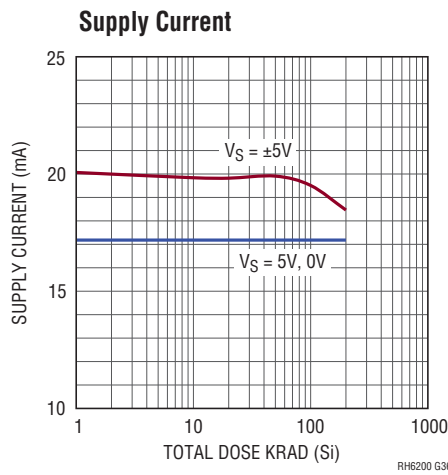
RH6200 G34

**Short-Circuit Current**



RH6200 G35

## TYPICAL PERFORMANCE CHARACTERISTICS



## REVISION HISTORY

REV	DATE	DESCRIPTION	PAGE NUMBER
A	11/11	Revised Conditions for $A_{VOL}$ in Table 1: Electrical Characteristics	2
B	07/23	Updated art title in the Electrical Characteristics section and updated the document to ADI format	1-10