



1.1 nV/ $\sqrt{\text{Hz}}$ Noise, Low Power, Precision Operational Amplifier

 Check for Samples: [OPA211-HT](#)

FEATURES

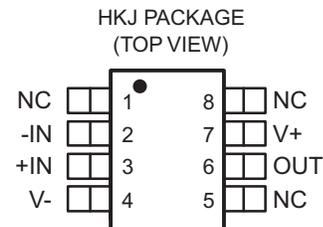
- Low Voltage Noise: 1.1 nV/ $\sqrt{\text{Hz}}$ at 1 kHz
- Input Voltage Noise: 80 nV_{PP} (0.1 Hz to 10 Hz)
- THD+N: –136 dB (G = 1, f = 1 kHz)
- Offset Voltage: 240 μV (max)
- Offset Voltage Drift: 0.35 $\mu\text{V}/^\circ\text{C}$ (typ)
- Low Supply Current: 6.0 mA/Ch (typ)
- Unity-Gain Stable
- Gain Bandwidth Product: 80 MHz (G = 100)
45 MHz (G = 1)
- Slew Rate: 27 V/ μs
- 16-Bit Settling: 700 ns
- Wide Supply Range: $\pm 2.25\text{ V}$ to $\pm 18\text{ V}$, 4.5 V to 36 V
- Rail-To-Rail Output
- Output Current: 30 mA

APPLICATIONS

- Down-Hole Drilling
- High Temperature Environments

SUPPORTS EXTREME TEMPERATURE APPLICATIONS

- Controlled Baseline
- One Assembly/Test Site
- One Fabrication Site
- Available in Extreme ($-55^\circ\text{C}/210^\circ\text{C}$) Temperature Range⁽¹⁾
- Extended Product Life Cycle
- Extended Product-Change Notification
- Product Traceability
- Texas Instruments high temperature products utilize highly optimized silicon (die) solutions with design and process enhancements to maximize performance over extended temperatures.



NC denotes no internal connection

(1) Custom temperature ranges available

DESCRIPTION

The OPA211 series of precision operational amplifiers achieves very low 1.1 nV/ $\sqrt{\text{Hz}}$ noise density with a supply current of only 3.6 mA. This series also offers rail-to-rail output swing, which maximizes dynamic range.

The extremely low voltage and low current noise, high speed, and wide output swing of the OPA211 series make these devices an excellent choice as a loop filter amplifier in PLL applications.

In precision data acquisition applications, the OPA211 series of op amps provides 700-ns settling time to 16-bit accuracy throughout 10-V output swings. This ac performance, combined with only 240- μV of offset and 0.35- $\mu\text{V}/^\circ\text{C}$ of drift over temperature, makes the OPA211 ideal for driving high-precision 16-bit analog-to-digital converters (ADCs) or buffering the output of high-resolution digital-to-analog converters (DACs).

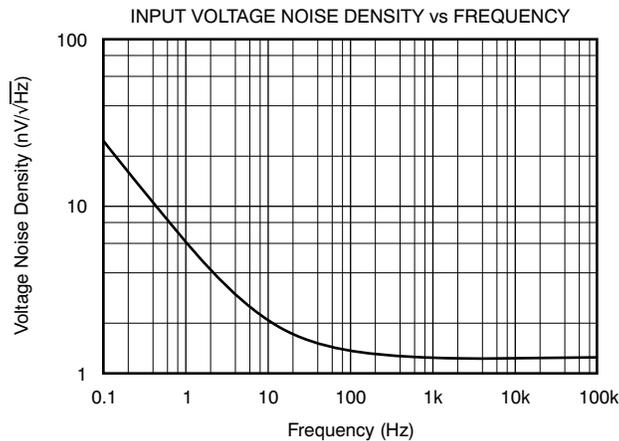
The OPA211 series is specified over a wide dual-power supply range of $\pm 2.25\text{ V}$ to $\pm 18\text{ V}$, or for single-supply operation from 4.5 V to 36 V.

This series of op amps is specified from $T_A = -55^\circ\text{C}$ to 210°C .



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

Over operating free-air temperature range (unless otherwise noted).

		VALUE	UNIT
$V_S = (V_+) - (V_-)$	Supply Voltage	40	V
V_{IN}	Input Voltage	$(V_-) - 0.5$ to $(V_+) + 0.5$	V
I_{IN}	Input Current (Any pin except power-supply pins)	±10	mA
	Output Short-Circuit ⁽²⁾	Continuous	
T_A	Operating Temperature	-55 to 210	°C
T_{STG}	Storage Temperature	-65 to 210	°C
T_J	Junction Temperature	210	°C
ESD Ratings	Human Body Model (HBM)	3000	V
	Charged Device Model (CDM)	1000	V

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not supported.

(2) Short-circuit to $V_S/2$ (ground in symmetrical dual supply setups), one amplifier per package.

THERMAL CHARACTERISTICS FOR HKJ PACKAGE

over operating free-air temperature range (unless otherwise noted)

PARAMETER		MIN	TYP	MAX	UNIT
θ_{JC}	Junction-to-case thermal resistance (to botom of case)			5.7	°C/W
	Junction-to-case thermal resistance (to top of case lid - as if formed dead bug)			13.7	

Table 1. ORDERING INFORMATION⁽¹⁾

TA	PACKAGE ⁽²⁾	ORDERABLE PART NUMBER	TOP-SIDE MARKING
-55°C to 210°C	HKJ	OPA211SHKJ	OPA211SHKJ
	KGD	OPA211SKGD1	NA

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI Web site at www.ti.com.

(2) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

BARE DIE INFORMATION

DIE THICKNESS	BACKSIDE FINISH	BACKSIDE POTENTIAL	BOND PAD METALLIZATION COMPOSITION
15 mils.	Silicon with backgrind	V-	Al-Si-Cu (0.5%)

Origin

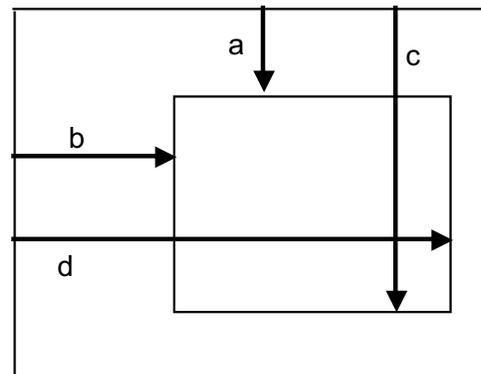
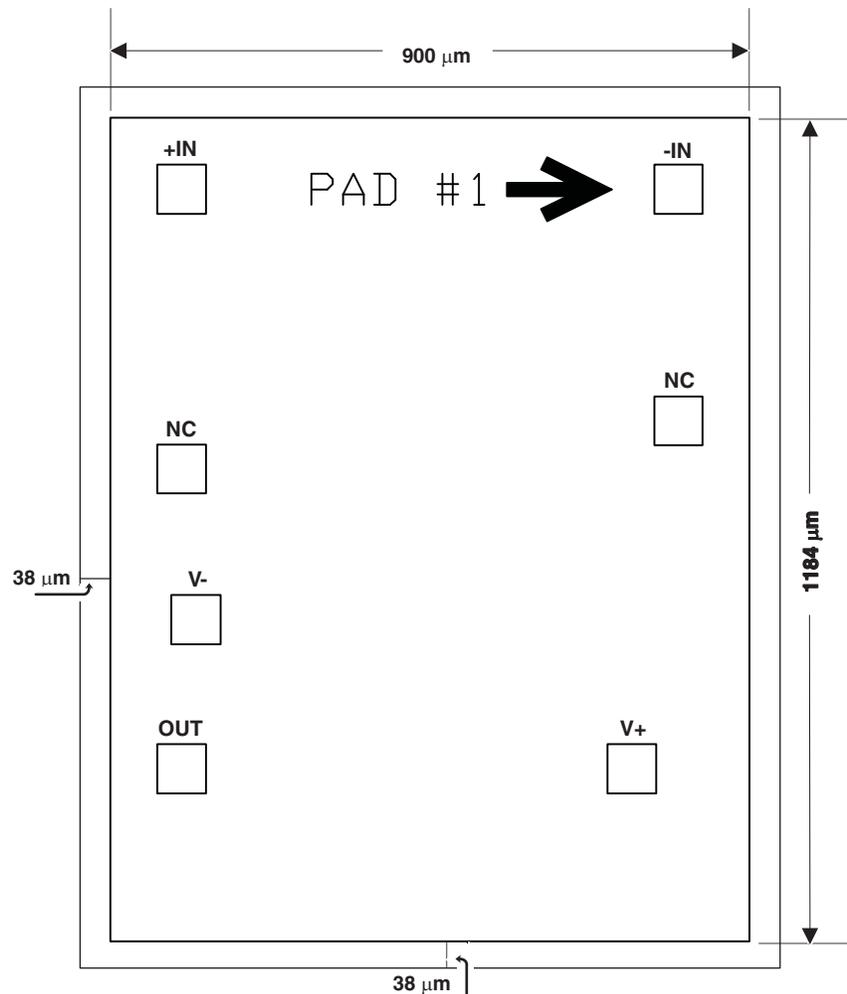


Table 2. BOND PAD COORDINATES

DESCRIPTION	PAD NUMBER	a	b	c	d
-IN	1	34.400	792.000	109.400	867.000
+IN	2	34.400	33.000	109.400	108.000
NC	3	461.850	33.000	536.850	108.000
V-	4	692.650	54.600	767.650	129.600
OUT	5	920.400	33.000	995.400	108.000
V+	6	920.400	720.150	995.400	795.150
NC	7	388.050	792.000	463.050	795.150



ELECTRICAL CHARACTERISTICS: $V_S = \pm 2.25\text{ V}$ to $\pm 18\text{ V}$

 At $T_A = 25^\circ\text{C}$, $R_L = 10\text{ k}\Omega$ connected to midsupply, $V_{CM} = V_{OUT} = \text{midsupply}$, unless otherwise noted.

PARAMETER	CONDITIONS	$T_A = -55\text{ to }125^\circ\text{C}$			$T_A = 210^\circ\text{C}$			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
OFFSET VOLTAGE								
Input Offset Voltage	V_{OS}	$V_S = \pm 15\text{V}$	± 30	± 180	± 70	± 260	μV	
Drift	dV_{OS}/dT		0.35	1.5	0.35	2.0	$\mu\text{V}/^\circ\text{C}$	
vs Power Supply	PSRR	$V_S = \pm 2.25\text{V to } \pm 18\text{V}$	0.1	3	0.1	3	$\mu\text{V/V}$	
INPUT BIAS CURRENT								
Input Bias Current	I_B	$V_{CM} = 0\text{V}$	± 60	± 200	± 60	± 250	nA	
Offset Current	I_{OS}	$V_{CM} = 0\text{V}$	± 25	± 150	± 25	± 150	nA	
NOISE								
Input Voltage Noise	e_n	$f = 0.1\text{Hz to } 10\text{Hz}$	80		80		nV_{pp}	
Input Voltage Noise Density		$f = 10\text{Hz}$	2		2		$\text{nV}/\sqrt{\text{Hz}}$	
		$f = 100\text{Hz}$	1.4		1.4		$\text{nV}/\sqrt{\text{Hz}}$	
		$f = 1\text{kHz}$	1.1		1.1		$\text{nV}/\sqrt{\text{Hz}}$	
Input Current Noise Density	I_n	$f = 10\text{Hz}$	3.2		3.2		$\text{pA}/\sqrt{\text{Hz}}$	
		$f = 1\text{kHz}$	1.7		1.7		$\text{pA}/\sqrt{\text{Hz}}$	
INPUT VOLTAGE RANGE								
Common-Mode Voltage Range	V_{CM}	$V_S \geq \pm 5\text{V}$	$(V-) + 1.8$	$(V+) - 1.4$	$(V-) + 1.8$	$(V+) - 1.4$	V	
		$V_S < \pm 5\text{V}$	$(V-) + 2$	$(V+) - 1.4$	$(V-) + 2$	$(V+) - 1.4$	V	
Common-Mode Rejection Ratio	CMRR	$V_S \geq \pm 5\text{V}, (V-) + 2\text{V} \leq V_{CM} \leq (V+) - 2\text{V}$	114	120	113	120	dB	
		$V_S < \pm 5\text{V}, (V-) + 2\text{V} \leq V_{CM} \leq (V+) - 2\text{V}$	108	120	93	100	dB	
INPUT IMPEDANCE								
Differential			$20\text{k} \parallel 8$		$20\text{k} \parallel 8$		$\Omega \parallel \text{pF}$	
Common-Mode			$10^9 \parallel 2$		$10^9 \parallel 2$		$\Omega \parallel \text{pF}$	
OPEN-LOOP GAIN								
Open-Loop Voltage Gain	A_{OL}	$(V-) + 0.2\text{V} \leq V_O \leq (V+) - 0.2\text{V}, R_L = 10\text{k}\Omega$	114	130	112	118	dB	
	A_{OL}	$(V-) + 0.6\text{V} \leq V_O \leq (V+) - 0.6\text{V}, R_L = 600\Omega$	110	114	90	93	dB	
FREQUENCY RESPONSE								
Gain-Bandwidth Product	GBW	$G = 100$	80		80		MHz	
		$G = 1$	45		45		MHz	
Slew Rate	SR		27		27		$\text{V}/\mu\text{s}$	
Settling Time, 0.01%	t_s	$V_S = \pm 15\text{V}, G = -1, 10\text{V Step}, C_L = 100\text{pF}$	490		580		ns	
0.0015% (16-bit)		$V_S = \pm 15\text{V}, G = -1, 10\text{V Step}, C_L = 100\text{pF}$	700		750		ns	
Overload Recovery Time		$G = -10$	500		500		ns	
Total Harmonic Distortion + Noise	THD+N	$G = 1, f = 1\text{kHz}, V_O = 3V_{RMS}, R_L = 600\Omega$	0.000015		0.000015		%	
			-136		-136		dB	

ELECTRICAL CHARACTERISTICS: $V_S = \pm 2.25\text{ V}$ to $\pm 18\text{ V}$ (continued)

At $T_A = 25^\circ\text{C}$, $R_L = 10\text{ k}\Omega$ connected to midsupply, $V_{CM} = V_{OUT} = \text{midsupply}$, unless otherwise noted.

PARAMETER	CONDITIONS	$T_A = -55\text{ to }125^\circ\text{C}$			$T_A = 210^\circ\text{C}$			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
OUTPUT								
Voltage Output	V_{OUT}	$R_L = 10\text{ k}\Omega, A_{OL} \geq 114\text{ dB}$		$(V-) + 0.2$	$(V+) - 0.2$	$(V-) + 0.2$	$(V+) - 0.2$	V
		$R_L = 600\Omega, A_{OL} \geq 110\text{ dB}, \pm 18\text{ V}$		$(V-) + 0.6$	$(V+) - 0.6$	$(V-) + 1.2$	$(V+) - 0.6$	V
Short-Circuit Current	I_{SC}		+35/-50			+30/-45		mA
Capacitive Load Drive	C_{LOAD}		See Typical Characteristics					
Open-Loop Output Impedance	Z_O	$f = 1\text{ MHz}$		5				Ω
POWER SUPPLY								
Specified Voltage	V_S	± 2.25		± 18		± 2.25		± 18
Quiescent Current (per channel)	I_Q	$I_{OUT} = 0\text{ A}$		3.6		6.0		7.5
TEMPERATURE RANGE								
Specified range		-55°C to 210°C						
Operating range		-55°C to 210°C						

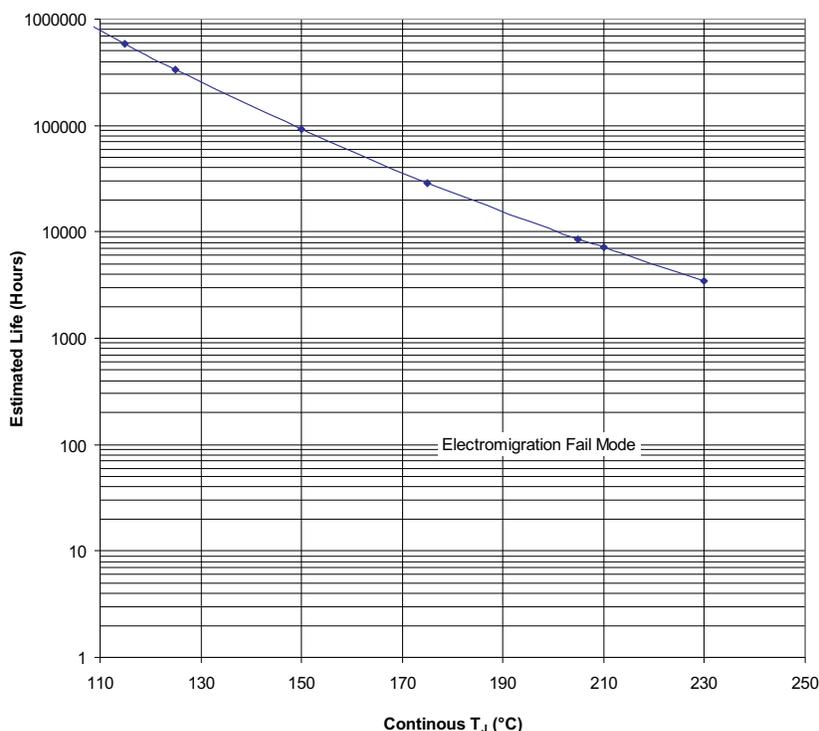


Figure 1. OPA211SKGD1 Operating Life Derating Chart

Notes:

1. See datasheet for absolute maximum and minimum recommended operating conditions.
2. Silicon operating life design goal is 10 years at 105°C junction temperature (does not include package interconnect life).

TYPICAL CHARACTERISTICS

At $T_A = 25^\circ\text{C}$, $V_S = \pm 18\text{ V}$, and $R_L = 10\text{ k}\Omega$, unless otherwise noted.

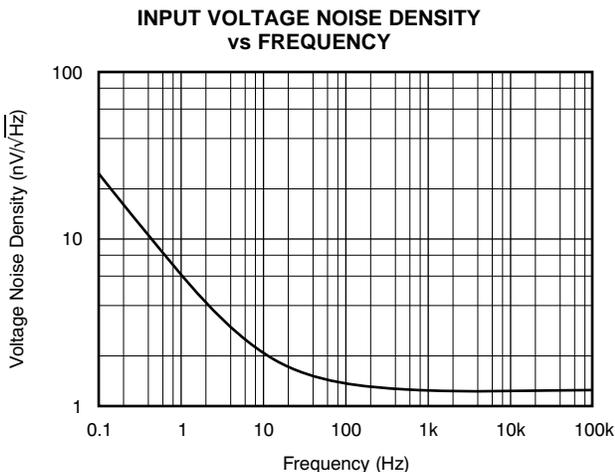


Figure 2.

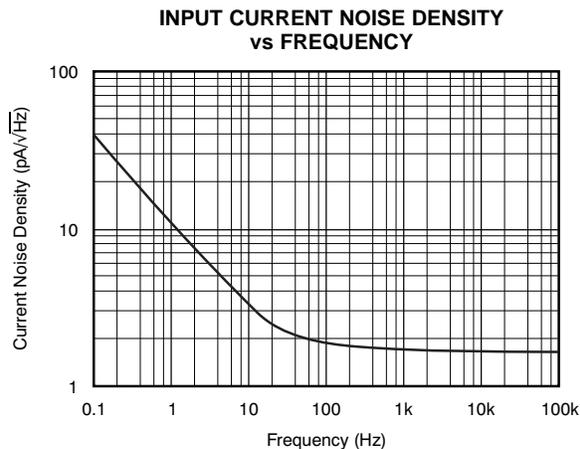


Figure 3.

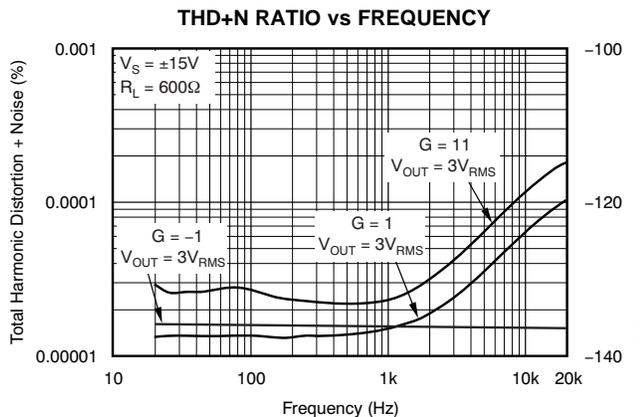


Figure 4.

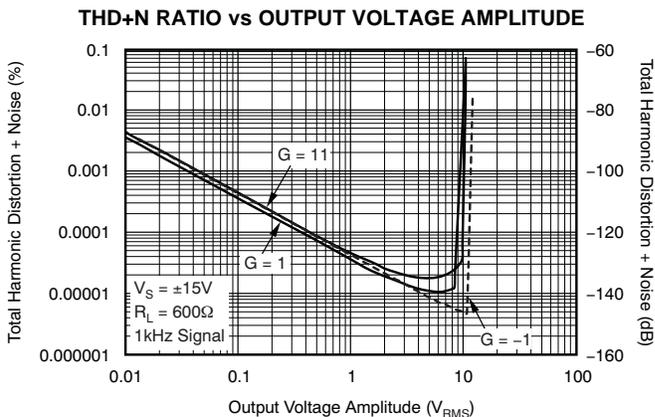


Figure 5.

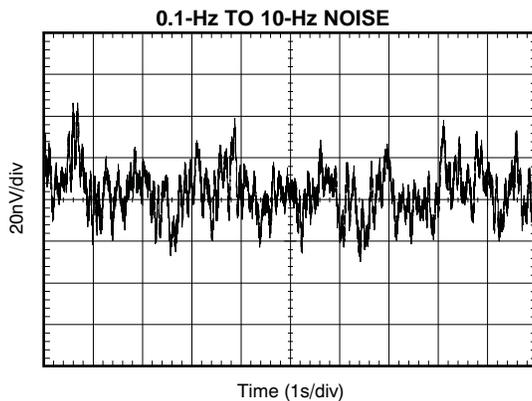


Figure 6.

TYPICAL CHARACTERISTICS (continued)

At $T_A = 25^\circ\text{C}$, $V_S = \pm 18\text{ V}$, and $R_L = 10\text{ k}\Omega$, unless otherwise noted.

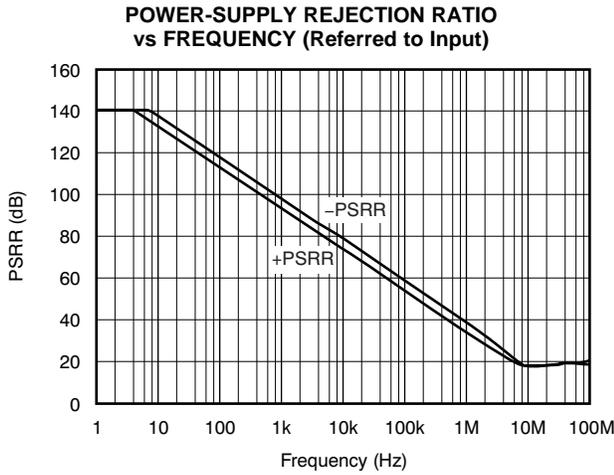


Figure 7.

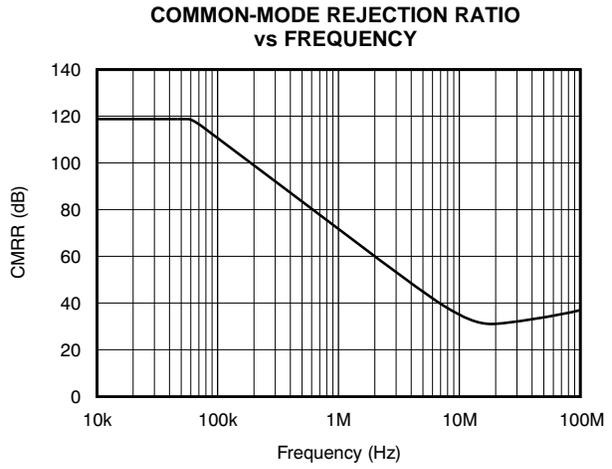


Figure 8.

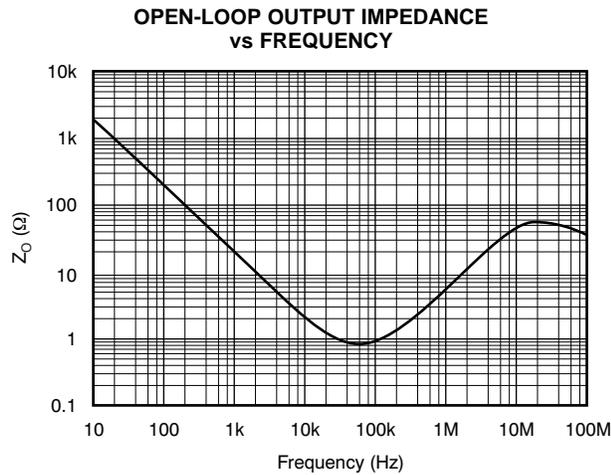


Figure 9.

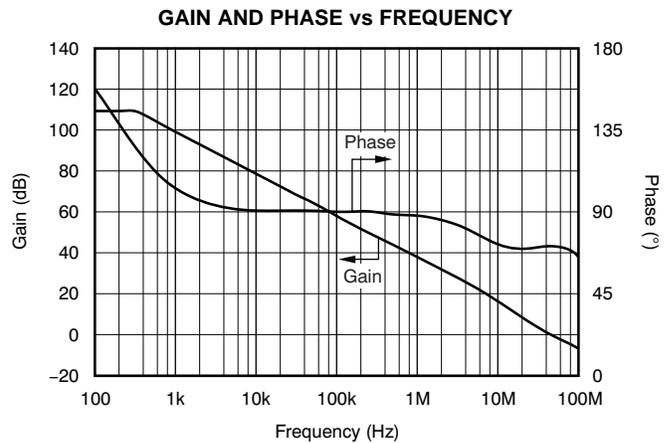


Figure 10.

**OPEN-LOOP GAIN vs TEMPERATURE
($R_L = 10\text{ k}\Omega$)**

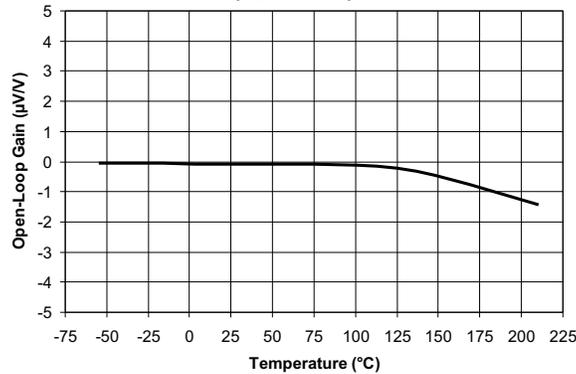


Figure 11.

TYPICAL CHARACTERISTICS (continued)

At $T_A = 25^\circ\text{C}$, $V_S = \pm 18\text{ V}$, and $R_L = 10\text{ k}\Omega$, unless otherwise noted.

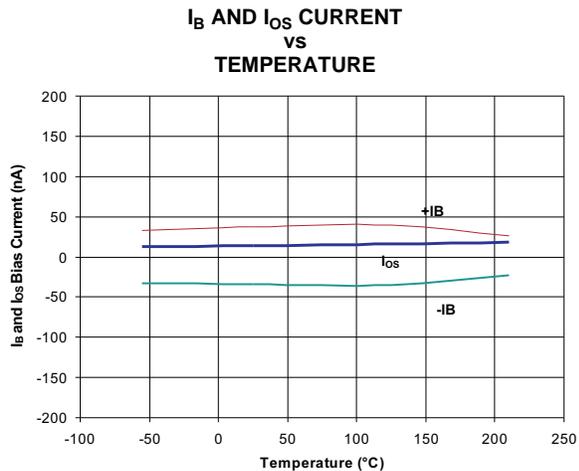


Figure 12.

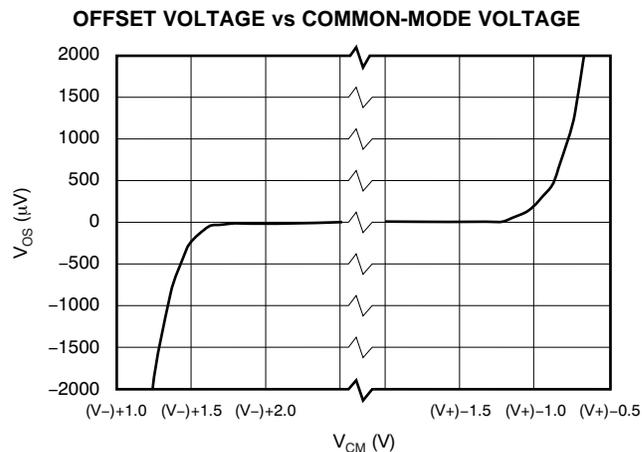


Figure 13.

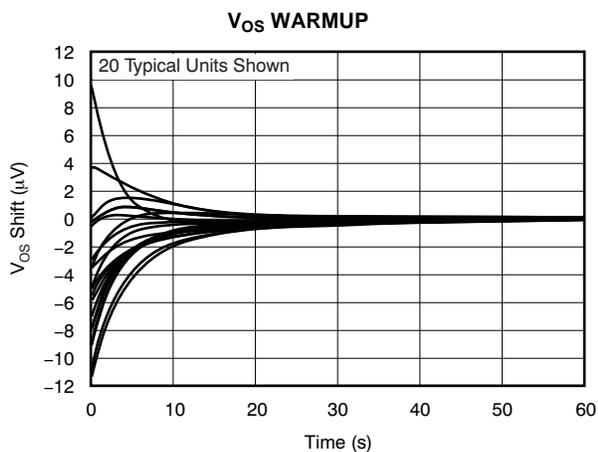


Figure 14.

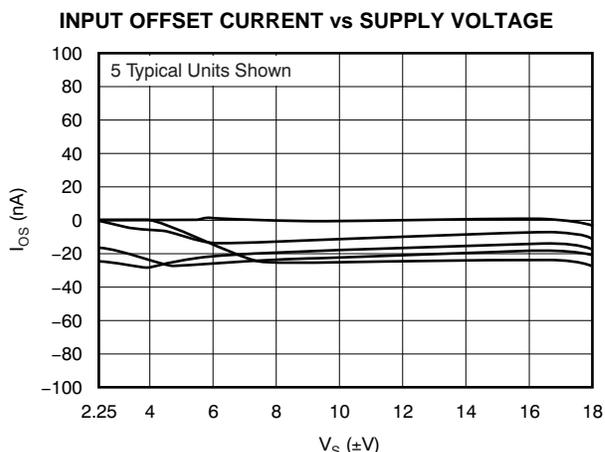


Figure 15.

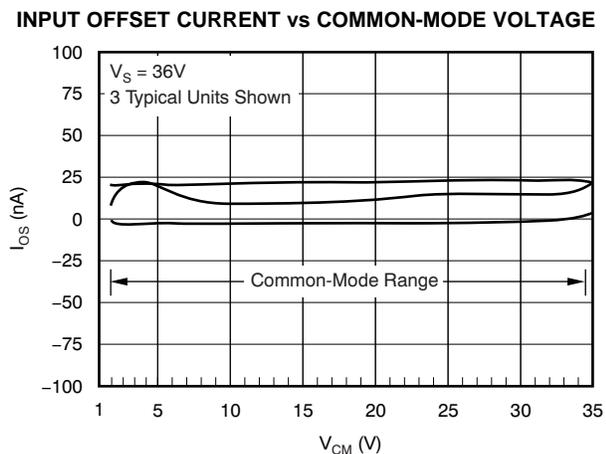


Figure 16.

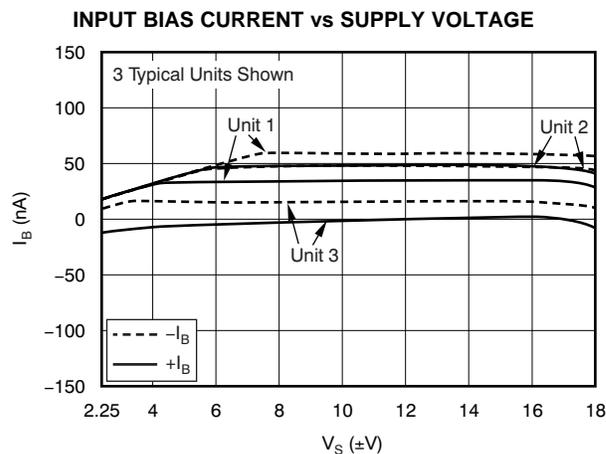


Figure 17.

TYPICAL CHARACTERISTICS (continued)

At $T_A = 25^\circ\text{C}$, $V_S = \pm 18\text{ V}$, and $R_L = 10\text{ k}\Omega$, unless otherwise noted.

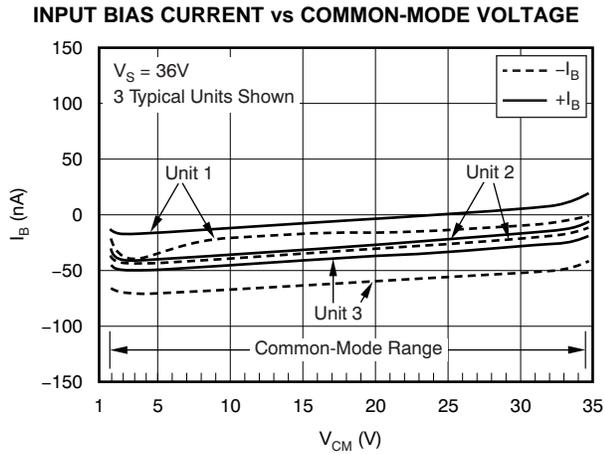


Figure 18.

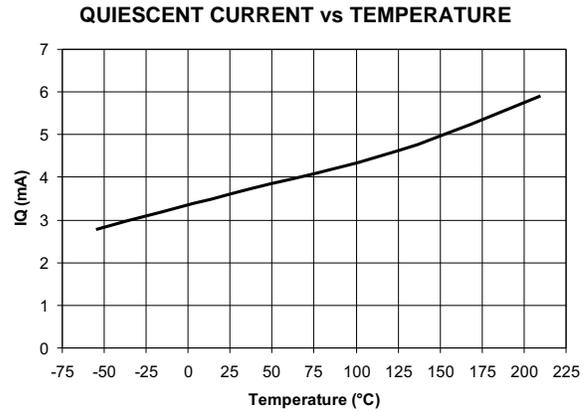


Figure 19.

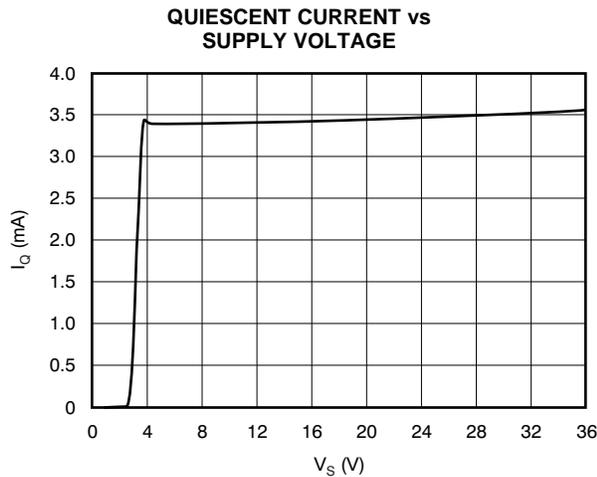


Figure 20.

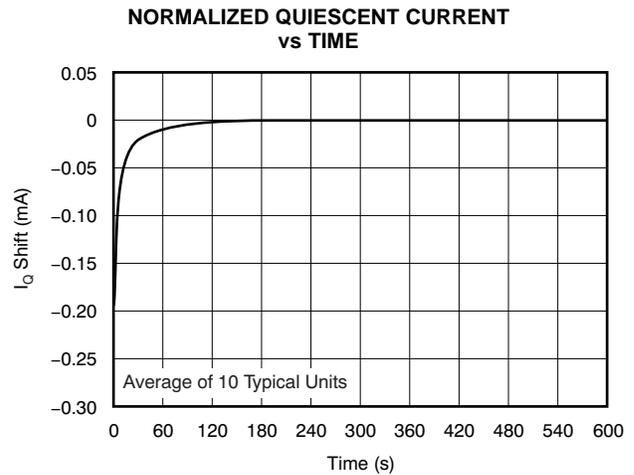


Figure 21.

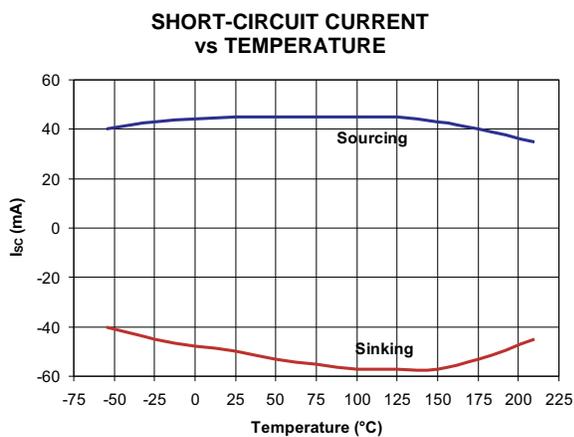


Figure 22.

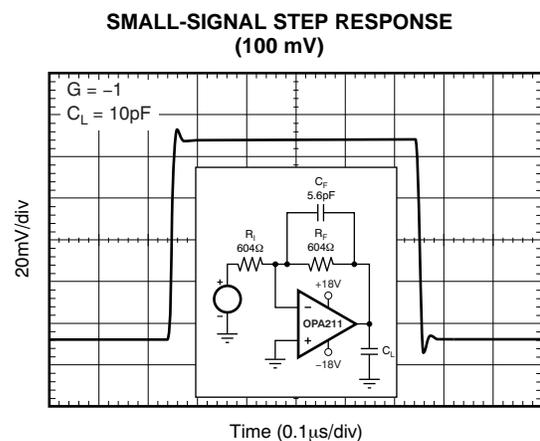


Figure 23.

TYPICAL CHARACTERISTICS (continued)

At $T_A = 25^\circ\text{C}$, $V_S = \pm 18\text{ V}$, and $R_L = 10\text{ k}\Omega$, unless otherwise noted.

SMALL-SIGNAL STEP RESPONSE
(100 mV)

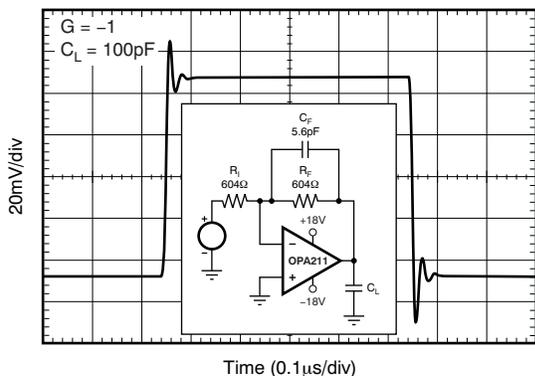


Figure 24.

SMALL-SIGNAL STEP RESPONSE
(100 mV)

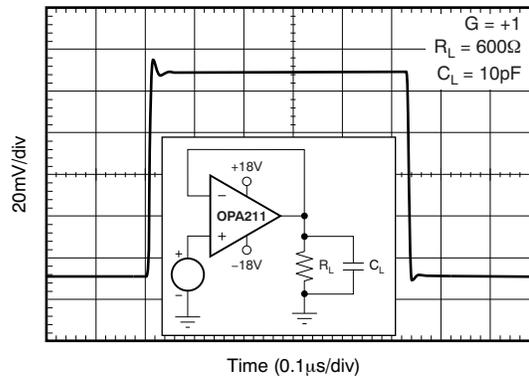


Figure 25.

SMALL-SIGNAL STEP RESPONSE
(100 mV)

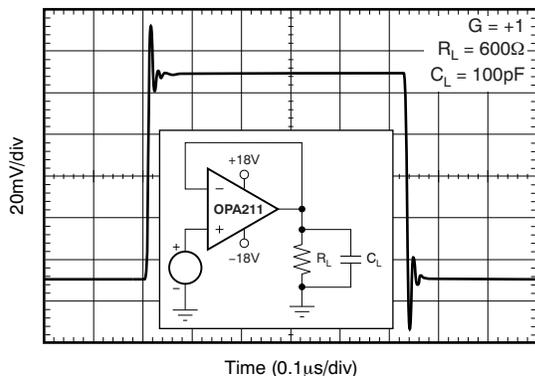


Figure 26.

SMALL-SIGNAL OVERSHOOT
vs CAPACITIVE LOAD (100-mV Output Step)

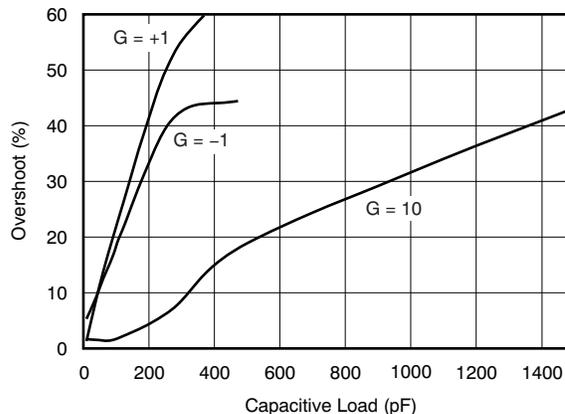


Figure 27.

LARGE-SIGNAL STEP RESPONSE

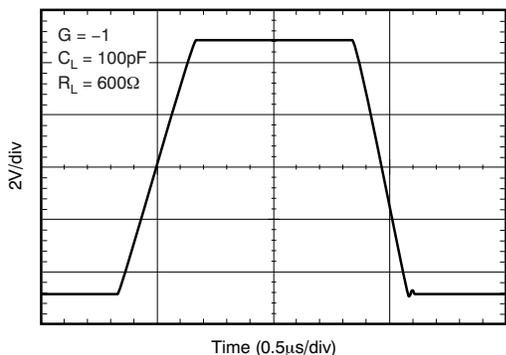


Figure 28.

LARGE-SIGNAL STEP RESPONSE

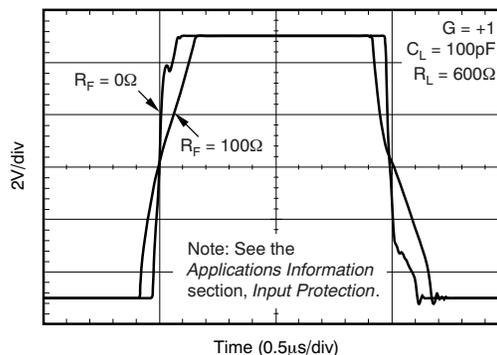


Figure 29.

TYPICAL CHARACTERISTICS (continued)

At $T_A = 25^\circ\text{C}$, $V_S = \pm 18\text{ V}$, and $R_L = 10\text{ k}\Omega$, unless otherwise noted.

LARGE-SIGNAL POSITIVE SETTLING TIME
(10 V_{PP}, C_L = 100 pF)

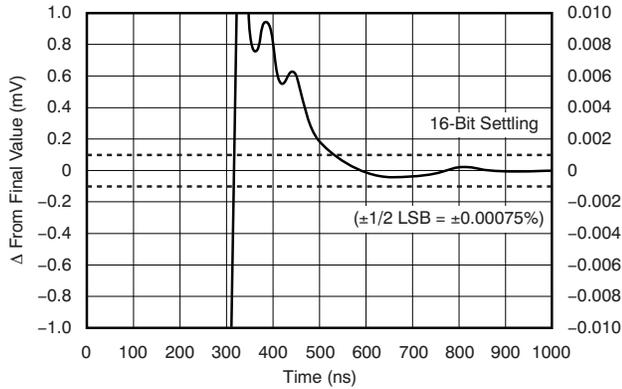


Figure 30.

LARGE-SIGNAL POSITIVE SETTLING TIME
(10 V_{PP}, C_L = 10 pF)

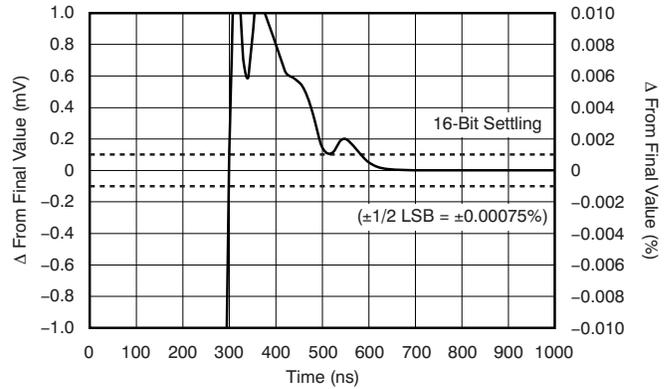


Figure 31.

LARGE-SIGNAL NEGATIVE SETTLING TIME
(10 V_{PP}, C_L = 100 pF)

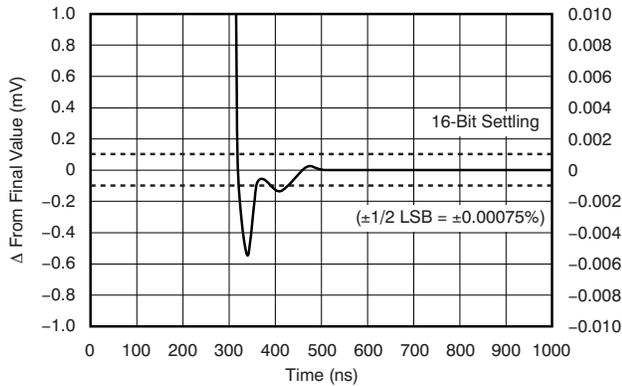


Figure 32.

LARGE-SIGNAL NEGATIVE SETTLING TIME
(10 V_{PP}, C_L = 10 pF)

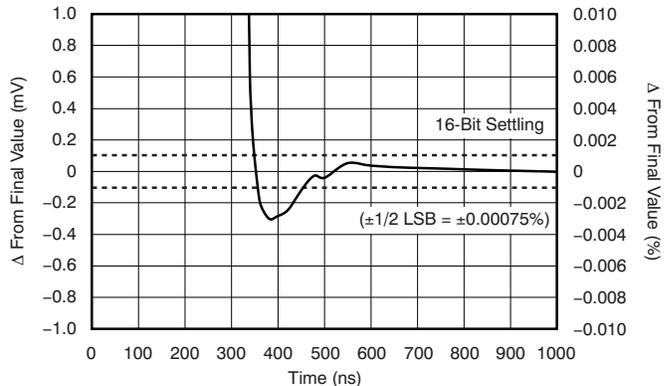


Figure 33.

NEGATIVE OVERLOAD RECOVERY

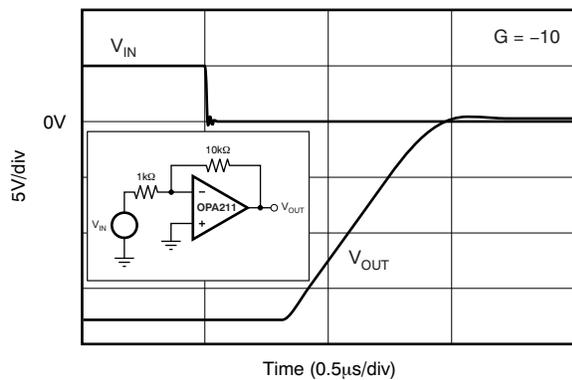


Figure 34.

POSITIVE OVERLOAD RECOVERY

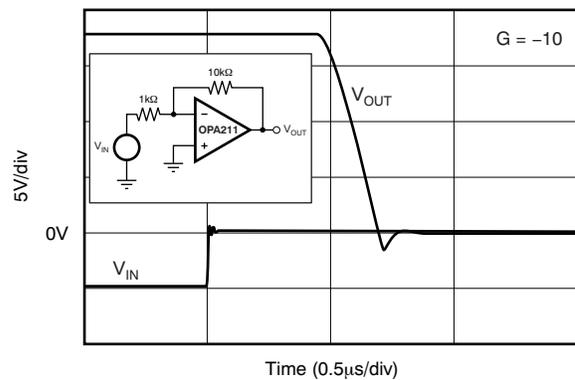


Figure 35.

TYPICAL CHARACTERISTICS (continued)

At $T_A = 25^\circ\text{C}$, $V_S = \pm 18\text{ V}$, and $R_L = 10\text{ k}\Omega$, unless otherwise noted.

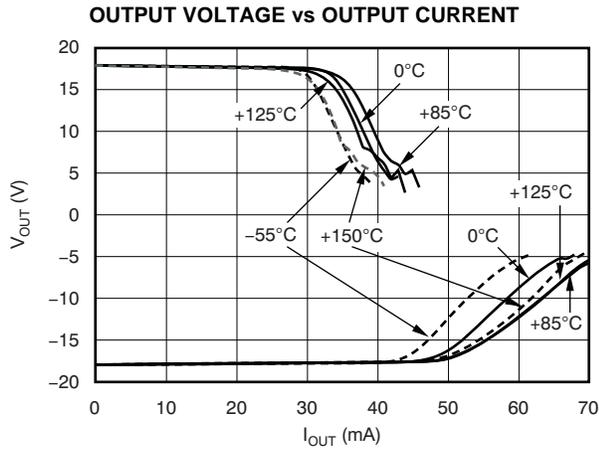


Figure 36.

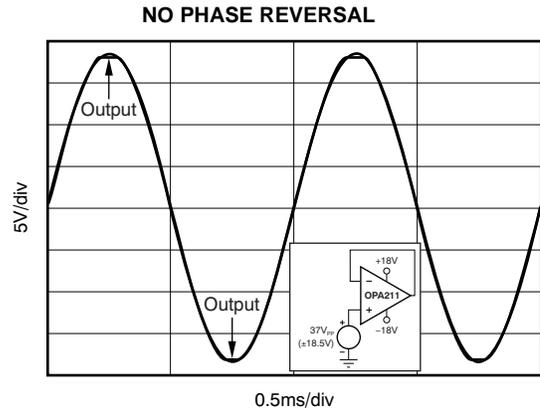


Figure 37.

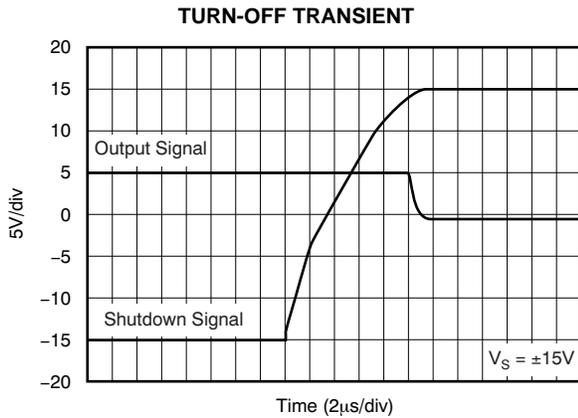


Figure 38.

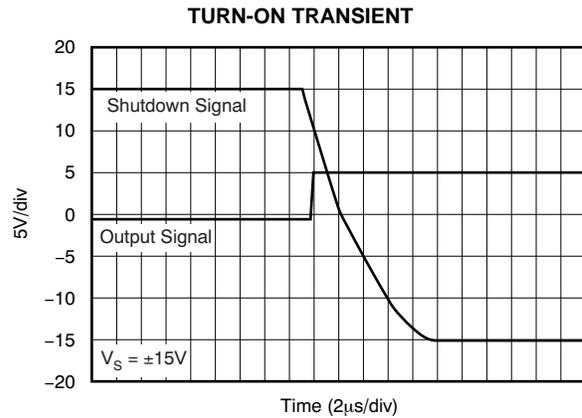


Figure 39.

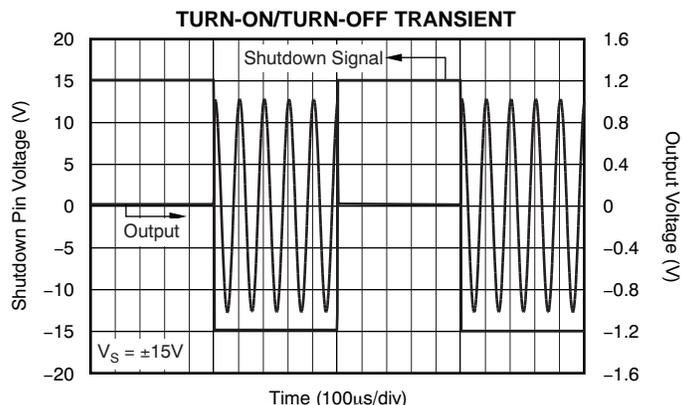


Figure 40.

APPLICATION INFORMATION

The OPA211 is a unity-gain stable, precision op amp with very low noise. Applications with noisy or high-impedance power supplies require decoupling capacitors close to the device pins. In most cases, 0.1- μ F capacitors are adequate. Figure 41 shows a simplified schematic of the OPA211. This die uses a SiGe bipolar process and contains 180 transistors.

OPERATING VOLTAGE

OPA211 series op amps operate from ± 2.25 -V to ± 18 -V supplies while maintaining excellent performance. The OPA211 series can operate with as little as 4.5 V between the supplies and with up to 36 V between the supplies. However, some applications

do not require equal positive and negative output voltage swing. With the OPA211 series, power-supply voltages do not need to be equal. For example, the positive supply could be set to 25 V with the negative supply at -5 V or vice-versa.

The common-mode voltage must be maintained within the specified range. In addition, key parameters are assured over the specified temperature range, $T_A = -55^\circ\text{C}$ to 210°C . Parameters that vary significantly with operating voltage or temperature are shown in the [Typical Characteristics](#).

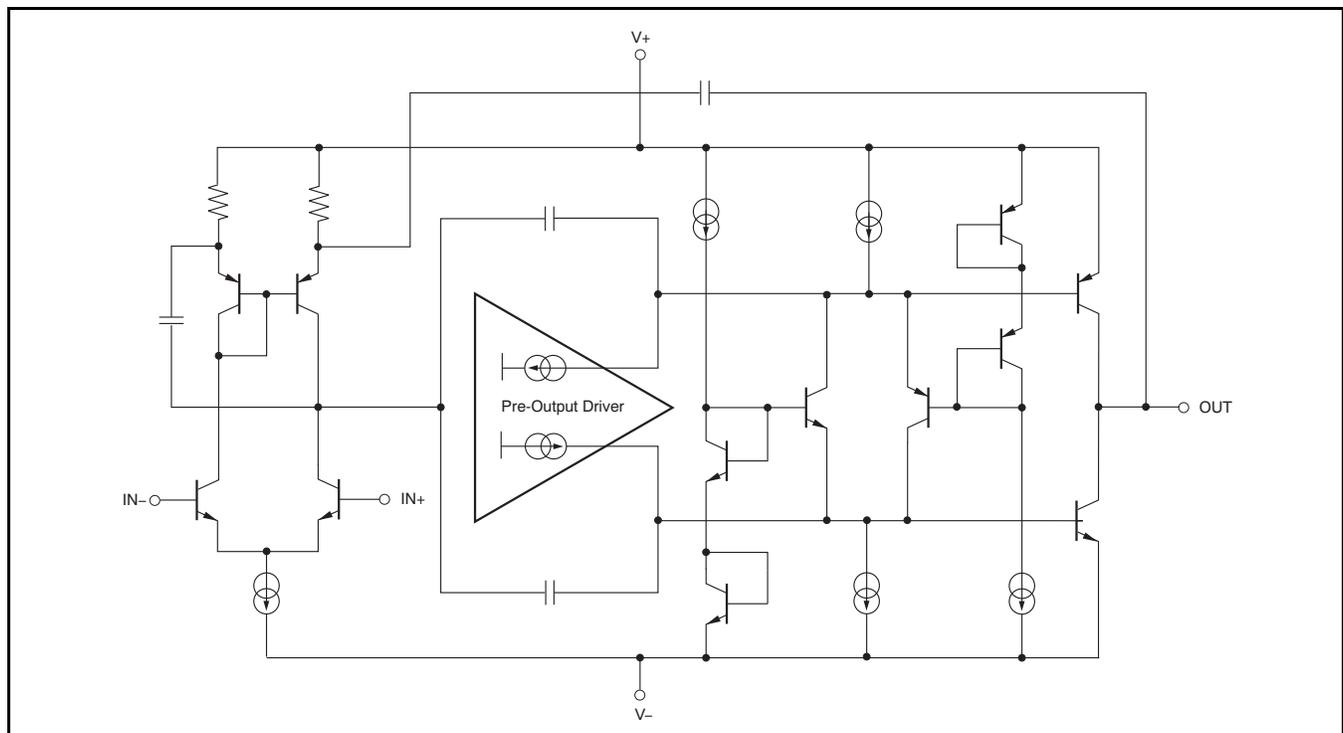


Figure 41. OPA211 Simplified Schematic

INPUT PROTECTION

The input terminals of the OPA211 are protected from excessive differential voltage with back-to-back diodes, as shown in Figure 42. In most circuit applications, the input protection circuitry has no consequence. However, in low-gain or $G = 1$ circuits, fast ramping input signals can forward bias these diodes because the output of the amplifier cannot respond rapidly enough to the input ramp. This effect is illustrated in Figure 29 of the Typical Characteristics. If the input signal is fast enough to create this forward bias condition, the input signal current must be limited to 10mA or less. If the input signal current is not inherently limited, an input series resistor can be used to limit the signal input current. This input series resistor degrades the low-noise performance of the OPA211, and is discussed in the *Noise Performance* section of this data sheet. Figure 42 shows an example implementing a current-limiting feedback resistor.

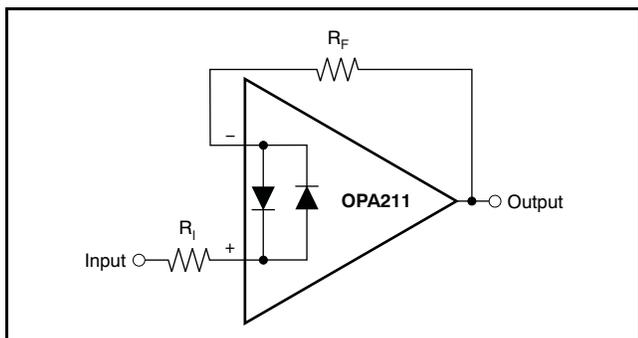


Figure 42. Pulsed Operation

NOISE PERFORMANCE

Figure 43 shows total circuit noise for varying source impedances with the op amp in a unity-gain configuration (no feedback resistor network, and therefore no additional noise contributions). Two different op amps are shown with total circuit noise calculated. The OPA211 has very low voltage noise, making it ideal for low source impedances (less than 2 k Ω). A similar precision op amp, the OPA227, has somewhat higher voltage noise but lower current noise. It provides excellent noise performance at moderate source impedance (10 k Ω to 100 k Ω). Above 100 k Ω , a FET-input op amp such as the OPA132 (very low current noise) may provide improved performance. The equation in Figure 43 is shown for the calculation of the total circuit noise. Note that e_n = voltage noise, I_n = current noise, R_S = source impedance, k = Boltzmann's constant = 1.38×10^{-23} J/K, and T is temperature in K.

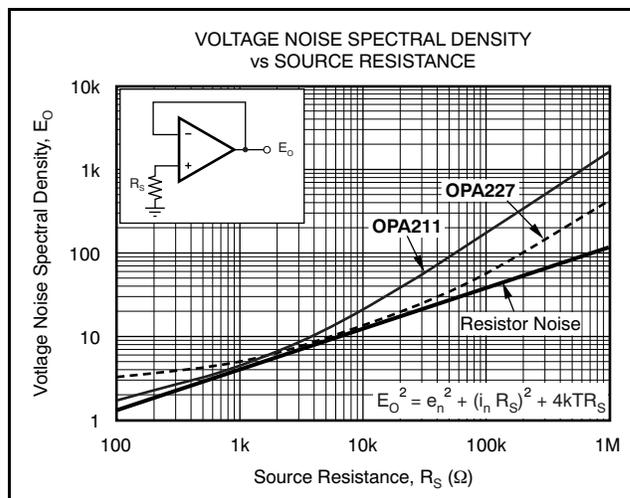


Figure 43. Noise Performance of the OPA211 and OPA227 in Unity-Gain Buffer Configuration

BASIC NOISE CALCULATIONS

Design of low-noise op amp circuits requires careful consideration of a variety of possible noise contributors: noise from the signal source, noise generated in the op amp, and noise from the feedback network resistors. The total noise of the circuit is the root-sum-square combination of all noise components.

The resistive portion of the source impedance produces thermal noise proportional to the square root of the resistance. This function is plotted in Figure 43. The source impedance is usually fixed; consequently, select the op amp and the feedback resistors to minimize the respective contributions to the total noise.

Figure 43 depicts total noise for varying source impedances with the op amp in a unity-gain configuration (no feedback resistor network, and therefore no additional noise contributions). The operational amplifier itself contributes both a voltage noise component and a current noise component. The voltage noise is commonly modeled as a time-varying component of the offset voltage. The current noise is modeled as the time-varying component of the input bias current and reacts with the source resistance to create a voltage component of noise. Therefore, the lowest noise op amp for a given application depends on the source impedance. For low source impedance, current noise is negligible and voltage noise generally dominates. For high source impedance, current noise may dominate.

Figure 44 illustrates both inverting and noninverting op amp circuit configurations with gain. In circuit configurations with gain, the feedback network resistors also contribute noise. The current noise of the op amp reacts with the feedback resistors to create additional noise components. The feedback resistor values can generally be chosen to make these noise sources negligible. The equations for total noise are shown for both configurations.

TOTAL HARMONIC DISTORTION MEASUREMENTS

OPA211 series op amps have excellent distortion characteristics. THD + Noise is below 0.0001% ($G = 1$, $V_O = 3 V_{RMS}$) throughout the audio frequency range, 20 Hz to 20 kHz, with a 600- Ω load.

The distortion produced by OPA211 series op amps is below the measurement limit of many commercially available distortion analyzers. However, a special test circuit illustrated in Figure 45 can be used to extend the measurement capabilities.

Op amp distortion can be considered an internal error source that can be referred to the input. Figure 45 shows a circuit that causes the op amp distortion to be 101 times greater than that normally produced by the op amp. The addition of R_3 to the otherwise standard noninverting amplifier configuration alters the feedback factor or noise gain of the circuit. The closed-loop gain is unchanged, but the feedback available for error correction is reduced by a factor of 101, thus extending the resolution by 101. Note that the input signal and load applied to the op amp are the same as with conventional feedback without R_3 . The value of R_3 should be kept small to minimize its effect on the distortion measurements.

Validity of this technique can be verified by duplicating measurements at high gain and/or high frequency where the distortion is within the measurement capability of the test equipment. Measurements for this data sheet were made with an Audio Precision System Two distortion/noise analyzer, which greatly simplifies such repetitive measurements. The measurement technique can, however, be performed with manual distortion measurement instruments.

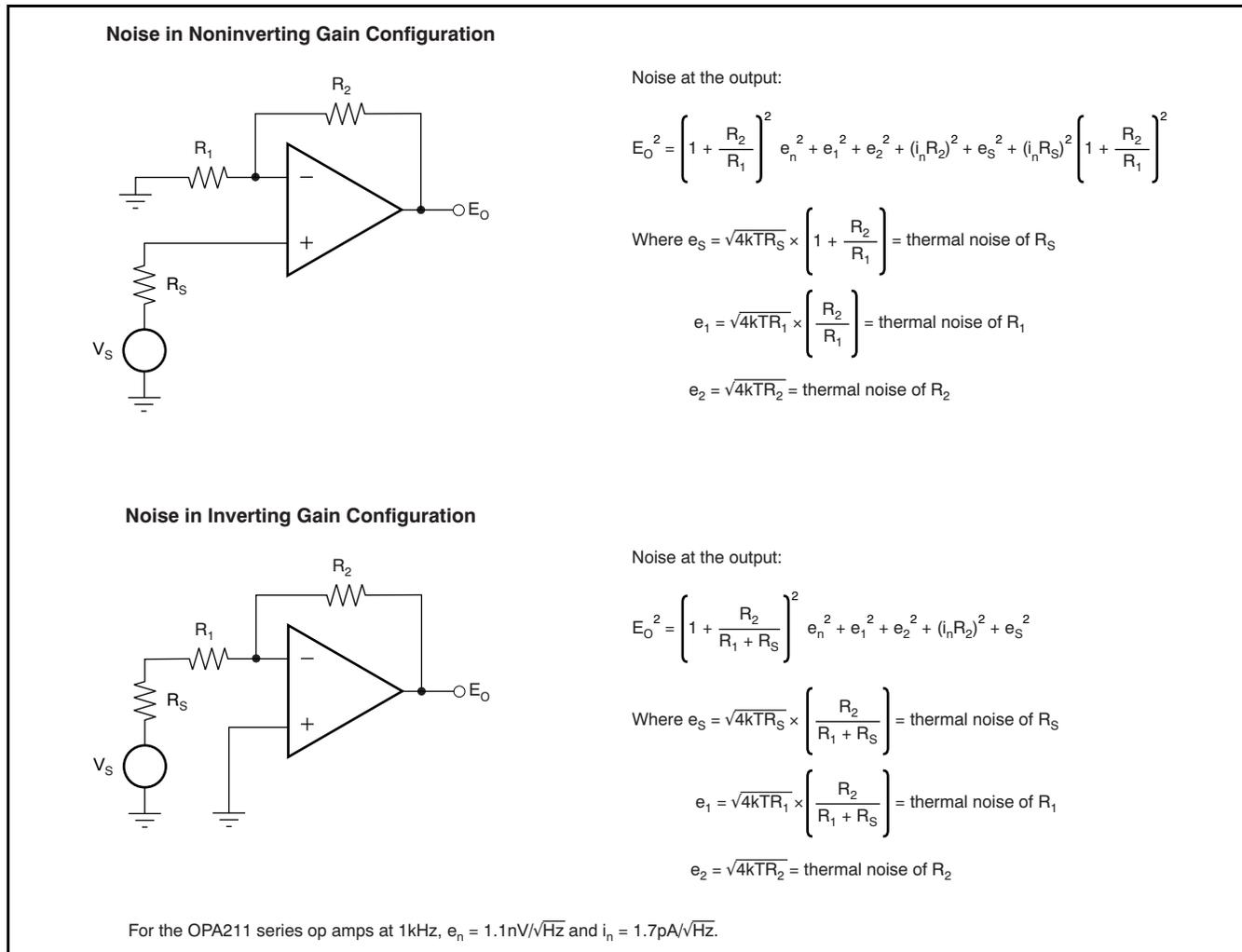


Figure 44. Noise Calculation in Gain Configurations

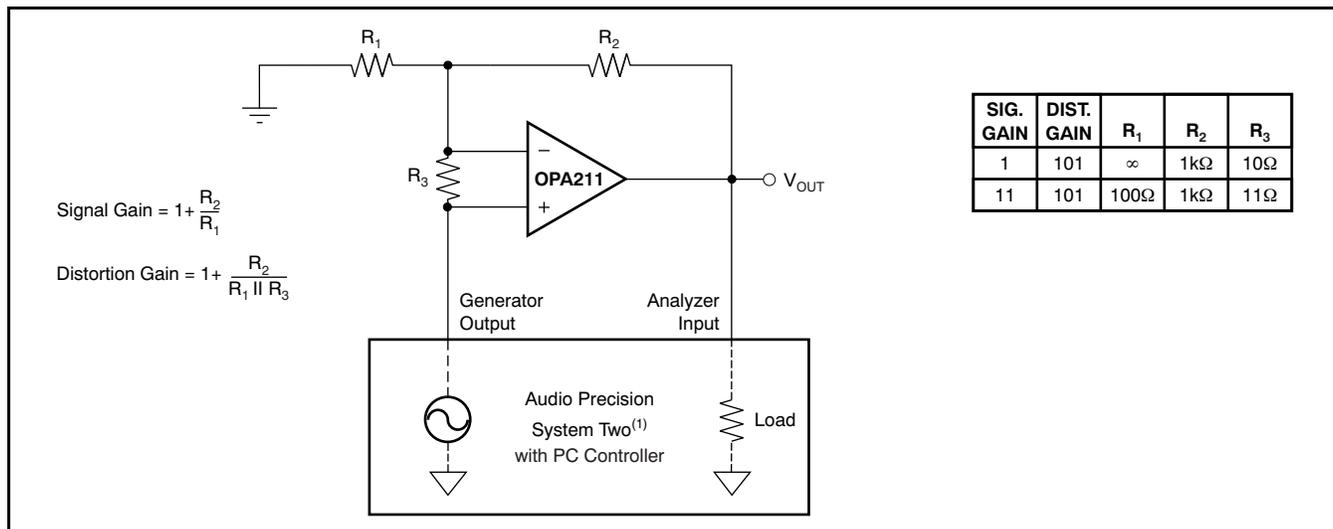


Figure 45. Distortion Test Circuit

ELECTRICAL OVERSTRESS

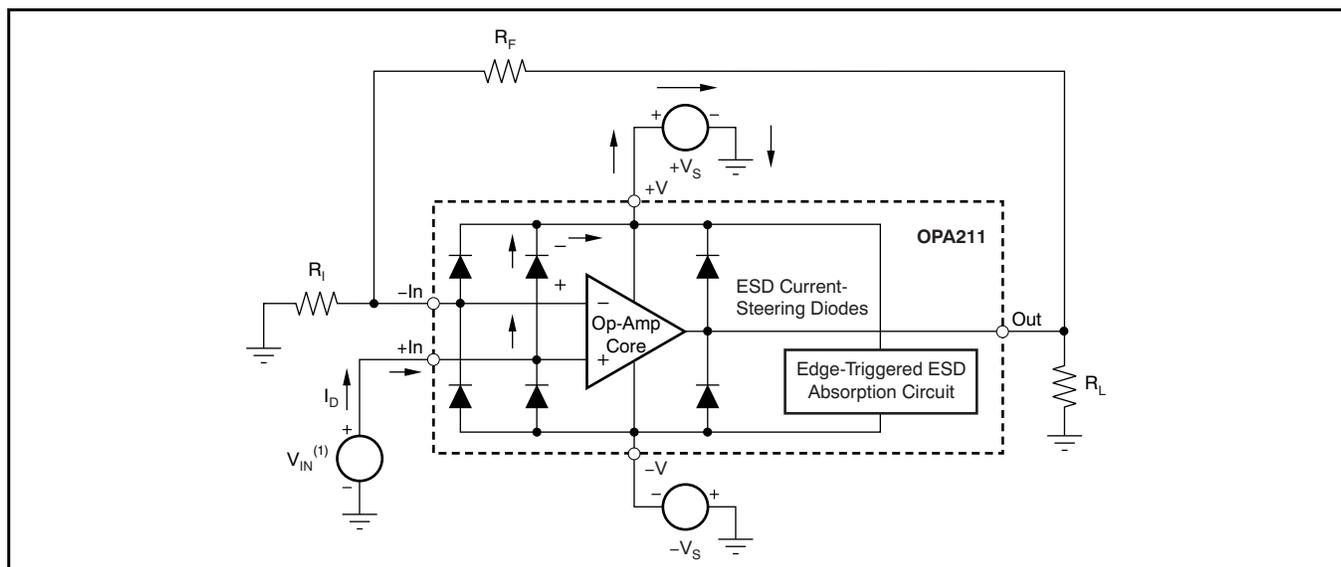
Designers often ask questions about the capability of an operational amplifier to withstand electrical overstress. These questions tend to focus on the device inputs, but may involve the supply voltage pins or even the output pin. Each of these different pin functions have electrical stress limits determined by the voltage breakdown characteristics of the particular semiconductor fabrication process and specific circuits connected to the pin. Additionally, internal electrostatic discharge (ESD) protection is built into these circuits to protect them from accidental ESD events both before and during product assembly.

It is helpful to have a good understanding of this basic ESD circuitry and its relevance to an electrical overstress event. Figure 46 illustrates the ESD circuits contained in the OPA211 (indicated by the dashed line area). The ESD protection circuitry involves several current-steering diodes connected from the input and output pins and routed back to the internal power-supply lines, where they meet at an absorption device internal to the operational amplifier. This protection circuitry is intended to remain inactive during normal circuit operation.

An ESD event produces a short duration, high-voltage pulse that is transformed into a short duration, high-current pulse as it discharges through a semiconductor device. The ESD protection circuits are designed to provide a current path around the operational amplifier core to prevent it from being damaged. The energy absorbed by the protection circuitry is then dissipated as heat.

When an ESD voltage develops across two or more of the amplifier device pins, current flows through one or more of the steering diodes. Depending on the path that the current takes, the absorption device may activate. The absorption device has a trigger, or threshold voltage, that is above the normal operating voltage of the OPA211 but below the device breakdown voltage level. Once this threshold is exceeded, the absorption device quickly activates and clamps the voltage across the supply rails to a safe level.

When the operational amplifier connects into a circuit such as that illustrated in Figure 46, the ESD protection components are intended to remain inactive and not become involved in the application circuit operation. However, circumstances may arise where an applied voltage exceeds the operating voltage range of a given pin. Should this condition occur, there is a risk that some of the internal ESD protection circuits may be biased on, and conduct current. Any such current flow occurs through steering diode paths and rarely involves the absorption device.



(1) $V_{IN} = +V_S + 500\text{mV}$.

Figure 46. Equivalent Internal ESD Circuitry and Its Relation to a Typical Circuit Application

Figure 46 depicts a specific example where the input voltage, V_{IN} , exceeds the positive supply voltage ($+V_S$) by 500 mV or more. Much of what happens in the circuit depends on the supply characteristics. If V_S can sink the current, one of the upper input steering diodes conducts and directs current to V_S . Excessively high current levels can flow with increasingly higher V_{IN} . As a result, the datasheet specifications recommend that applications limit the input current to 10 mA.

If the supply is not capable of sinking the current, V_{IN} may begin sourcing current to the operational amplifier, and then take over as the source of positive supply voltage. The danger in this case is that the voltage can rise to levels that exceed the operational amplifier absolute maximum ratings. In extreme but rare cases, the absorption device triggers on while V_S and $-V_S$ are applied. If this event happens, a direct current path is established between the V_S and $-V_S$ supplies. The power dissipation of the absorption device is quickly exceeded, and the extreme internal heating destroys the operational amplifier.

Another common question involves what happens to the amplifier if an input signal is applied to the input while the power supplies V_S and/or $-V_S$ are at 0 V. Again, it depends on the supply characteristic while at 0 V, or at a level below the input signal amplitude. If the supplies appear as high impedance, then the operational amplifier supply current may be supplied by the input source via the current steering diodes. This state is not a normal bias condition; the amplifier most likely will not operate normally. If the supplies are low impedance, then the current through the steering diodes can become quite high. The current level depends on the ability of the input source to deliver current, and any resistance in the input path.

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/ Ball Finish	MSL Peak Temp ⁽³⁾	Samples (Requires Login)
OPA211SHKJ	ACTIVE	CFP	HKJ	8	1	TBD	Call TI	N / A for Pkg Type	
OPA211SKGD1	ACTIVE	XCEPT	KGD	0	400	TBD	Call TI	N / A for Pkg Type	

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSELETE: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF OPA211-HT :

- Catalog: [OPA211](#)

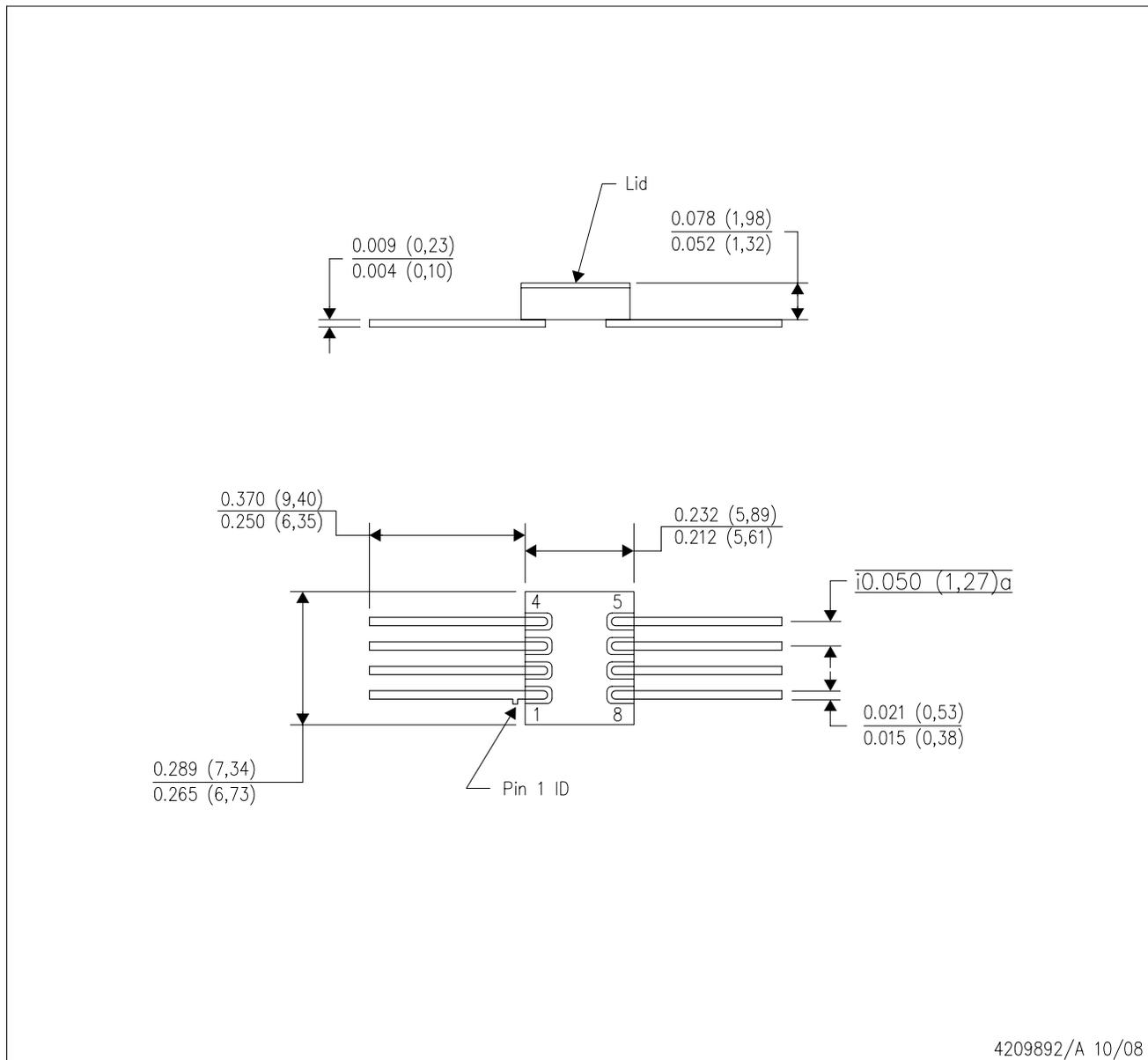
NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

MECHANICAL DATA

HKJ (R-CDFP-F8)

CERAMIC DUAL FLATPACK



4209892/A 10/08

- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. This package can be hermetically sealed with a metal lid.
 - D. The terminals will be gold plated.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
RF/IF and ZigBee® Solutions	www.ti.com/lprf

Applications

Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Transportation and Automotive	www.ti.com/automotive
Video and Imaging	www.ti.com/video
Wireless	www.ti.com/wireless-apps

TI E2E Community Home Page

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2011, Texas Instruments Incorporated