SGM8263-1/SGM8263-2
Ultra Low Offset Voltage, High Linearity, Low Noise Operational Amplifiers

GENERAL DESCRIPTION

The SGM8263-1 (single) and SGM8263-2 (dual) bipolar-input operational amplifiers achieve very low noise density with a low distortion of 0.0001% at 1kHz. The SGM8263-1/2 offer rail-to-rail output swing to within 190mV of supply rails with a 2kΩ load, which increases headroom and maximizes dynamic range. The devices also have a high output drive capability of ±55mA.

SGM8263-1/2 have ultra low offset voltage and ultra low offset voltage drift over temperature. The maximum offset voltage is 8.5μV. SGM8263-1/2 are very suitable for amplifying low noise and low amplitude signal.

The devices operate over a wide supply range of 4V to 36V or ±2V to ±18V, on only 2.5mA of supply current per amplifier. The SGM8263-1/2 operational amplifiers are unity-gain stable and provide excellent dynamic behavior over a wide range of load conditions.

The SGM8263-1 is available in Green SOT-23-5 and SOIC-8 packages. The SGM8263-2 is available in a Green SOIC-8 package. They are specified from -40℃ to +85℃ temperature range.

FEATURES

- **Ultra Low Offset Voltage: 8.5μV (MAX)**
- **Ultra Low Input Offset Voltage Drift: 10nV/℃**
- **Low Noise: 4.5nV/$\sqrt{Hz}$ at 1kHz**
- **Low Distortion: 0.0001% at 1kHz**
- **High Slew Rate: 10V/μs**
- **Gain-Bandwidth Product: 10MHz (G = +1)**
- **High Open-Loop Gain: 145dB**
- **Unity-Gain Stable**
- **Low Quiescent Current: 2.5mA/Amplifier**
- **Rail-to-Rail Output**
- **Support Single or Dual Power Supplies:**
  4V to 36V or ±2V to ±18V
- **-40℃ to +85℃ Operating Temperature Range**
- **Small Packaging:**
  SGM8263-1 Available in Green SOT-23-5 and SOIC-8 Packages
  SGM8263-2 Available in a Green SOIC-8 Package

APPLICATIONS

Temperature Measurements
Pressure Sensors
Precision Current Sensing
Electronic Scales
Strain Gauge Amplifiers
Medical Instrumentation
Thermocouple Amplifiers
Handheld Test Equipment

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8263-1	SOT-23-5	-40℃ to +85℃	SGM8263-1YN5G/TR	GJ8XX	Tape and Reel, 3000
	SOIC-8	-40℃ to +85℃	SGM8263-1YS8G/TR	SGM 82631YS8 XXXXX	Tape and Reel, 4000
SGM8263-2	SOIC-8	-40℃ to +85℃	SGM8263-2YS8G/TR	SGM 82632YS8 XXXXX	Tape and Reel, 4000

MARKING INFORMATION

NOTE: XX = Date Code. XXXXX = Date Code and Vendor Code.

SOT-23-5

YYY X X
- X — Date Code - Month
- X — Date Code - Year
- YYY — Serial Number

SOIC-8

XXXXX
- X — Vendor Code
- XX — Date Code - Week
- XX — Date Code - Year

Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, $+V_S$ to $-V_S$ 40V
Input Voltage Range .... $(-V_S) - 0.3V$ to $(+V_S) + 0.3V$
Input Current (All pins except power supply pins)....... ±10mA
Output Short-Circuit Current .... ±80mA
Junction Temperature .... +150℃
Storage Temperature Range......................... -65℃ to +150℃
Lead Temperature (Soldering, 10s) .... +260℃
ESD Susceptibility
HBM (SGM8263-1) 3000V
HBM (SGM8263-2) 5000V
MM (SGM8263-1) 200V
MM (SGM8263-2) 300V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Operating Temperature Range .... -40℃ to +85℃

OVERSTRESS CAUTION

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

ESD SENSITIVITY CAUTION

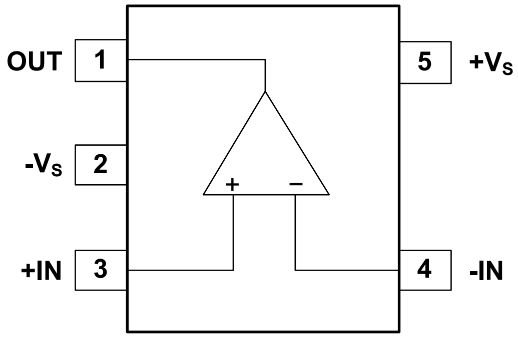
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because even small parametric changes could cause the device not to meet the published specifications.

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

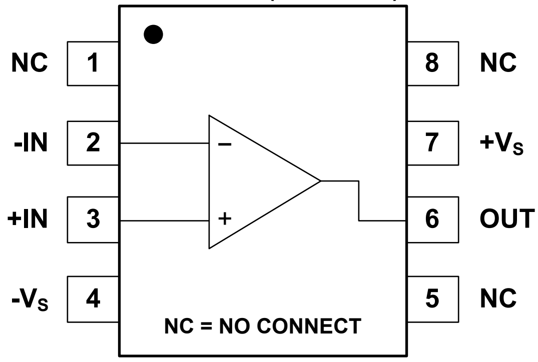
PIN CONFIGURATIONS

SGM8263-1 (TOP VIEW)



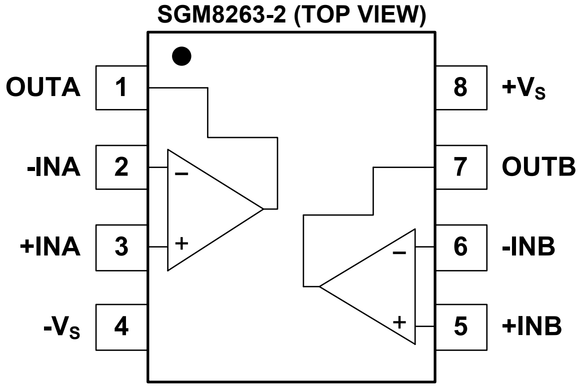
SOT-23-5

SGM8263-1 (TOP VIEW)



SOIC-8

SGM8263-2 (TOP VIEW)



SOIC-8

ELECTRICAL CHARACTERISTICS

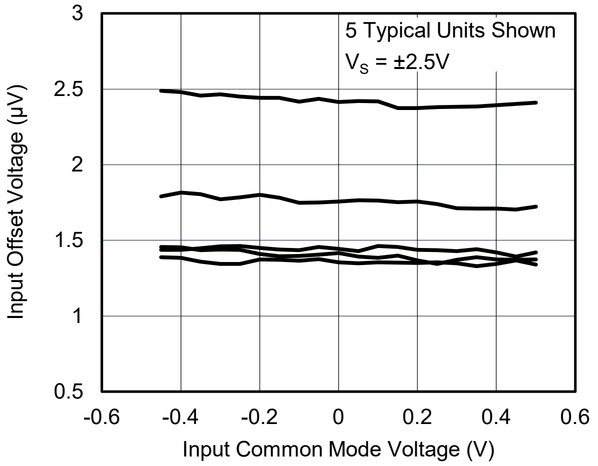
(At T_A = +25℃, V_S = 4.5V to 36V or V_S = ±2.25V to ±18V, R_L = 2kΩ, V_{CM} = V_{OUT} = V_S/2, Full = -40℃ to +85℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Input Characteristics							
Input Offset Voltage	V_{OS}	V_S = ±15V	+25℃		1.5	8.5	μV
			Full			10	
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		Full		10		nV/℃
Input Bias Current	I_B	V_{CM} = 0V	+25℃		±60	±300	nA
			Full			±350	
Input Offset Current	I_{OS}	V_{CM} = 0V	+25℃		±20	±190	nA
			Full			±210	
Input Common Mode Voltage Range	V_{CM}		Full	(-V_S) + 2		(+V_S) - 2	V
Common Mode Rejection Ratio	CMRR	(-V_S) + 2V ≤ V_{CM} ≤ (+V_S) - 2V	+25℃	107	135		dB
			Full	102			
Open-Loop Voltage Gain	A_{OL}	(-V_S) + 0.2V ≤ V_{OUT} ≤ (+V_S) - 0.2V, R_L = 10kΩ	+25℃	118	145		dB
			Full	115			
		(-V_S) + 0.6V ≤ V_{OUT} ≤ (+V_S) - 0.6V, R_L = 2kΩ	+25℃	115	145		
			Full	112			
Input Impedance							
Differential			+25℃		16k || 10		Ω || pF
Common Mode			+25℃		10^9 || 10		Ω || pF
Output Characteristics							
Output Voltage Swing from Rail		R_L = 10kΩ	+25℃		40	75	mV
			Full			85	
		R_L = 2kΩ	+25℃		190	320	
			Full			360	
Output Short-Circuit Current	I_{SC}		+25℃	±36	±55		mA
			Full	±27			
Dynamic Performance							
Gain-Bandwidth Product	GBP	G = +1	+25℃		10		MHz
Phase Margin	φ_O	V_{OUT} = 100mV_{P-P}, R_L = 2kΩ, C_L = 10pF	+25℃		50		°
Slew Rate	SR	G = -1, V_{OUT} = 2V_{P-P}	+25℃		10		V/μs
Settling Time to 0.1%	t_S	10V step, G = +1	+25℃		3		μs
Overload Recovery Time		V_{IN} × G > V_S	+25℃		0.2		μs
Total Harmonic Distortion + Noise	THD+N	G = +1, V_{OUT} = 1V_{RMS}, f = 1kHz, BW = 80kHz	+25℃		0.0001		%
Noise Performance							
Input Voltage Noise		f = 0.1Hz to 10Hz	+25℃		100		nV_{P-P}
Input Voltage Noise Density	e_n	f = 1kHz	+25℃		4.5		nV/$\sqrt{Hz}$
Input Current Noise Density	i_n	f = 1kHz	+25℃		5		pA/$\sqrt{Hz}$
Power Supply							
Supply Voltage	V_S		Full	±2		±18	V
Quiescent Current/Amplifier	I_Q	I_{OUT} = 0A	+25℃		2.5	3.2	mA
			Full			3.4	
Power Supply Rejection Ratio	PSRR	V_S = ±2V to ±18V	+25℃		0.02	0.4	μV/V
			Full			0.6	

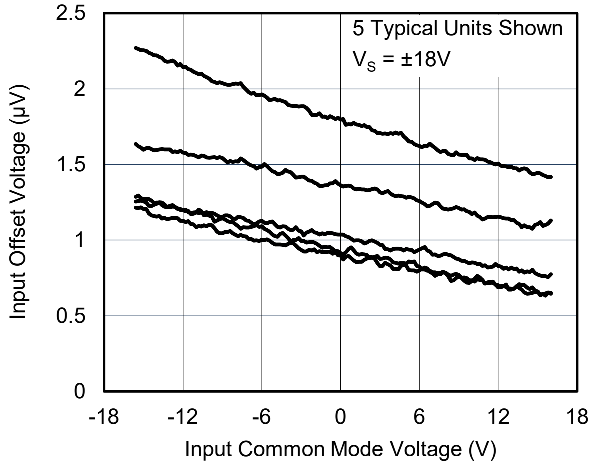
TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, V_S = ±18V and R_L = 10kΩ, unless otherwise noted.

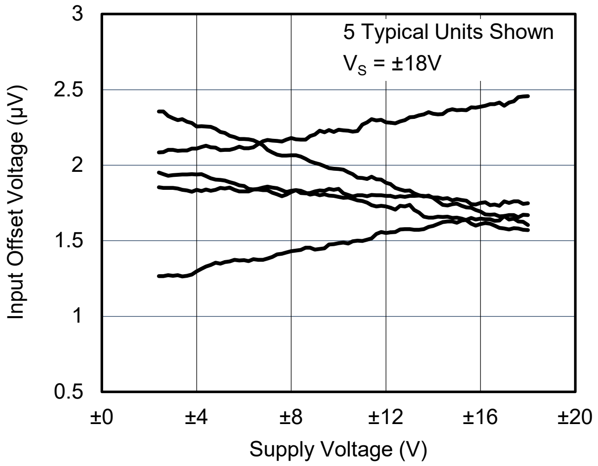
Input Offset Voltage vs. Input Common Mode Voltage



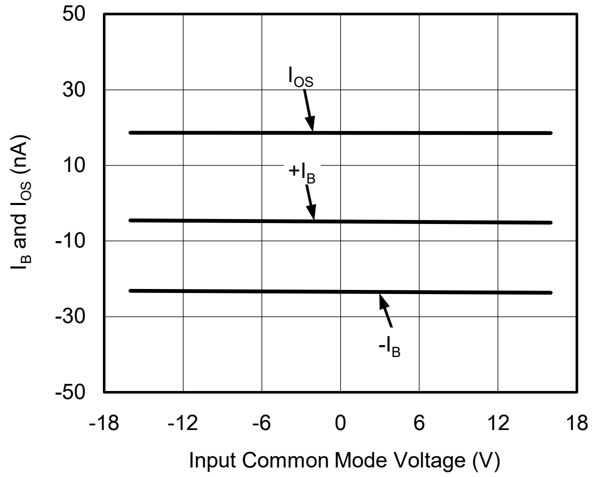
Input Offset Voltage vs. Input Common Mode Voltage



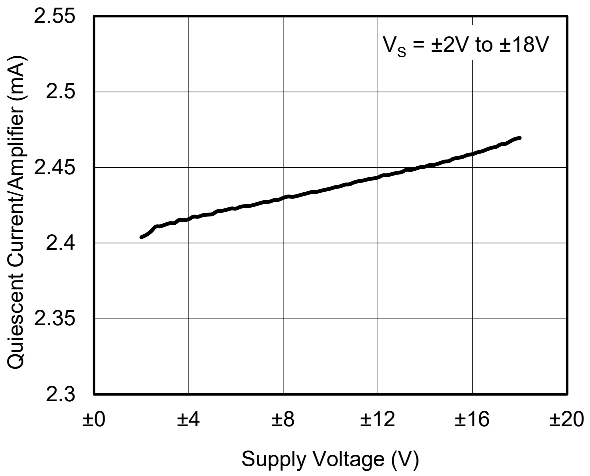
Input Offset Voltage vs. Supply Voltage



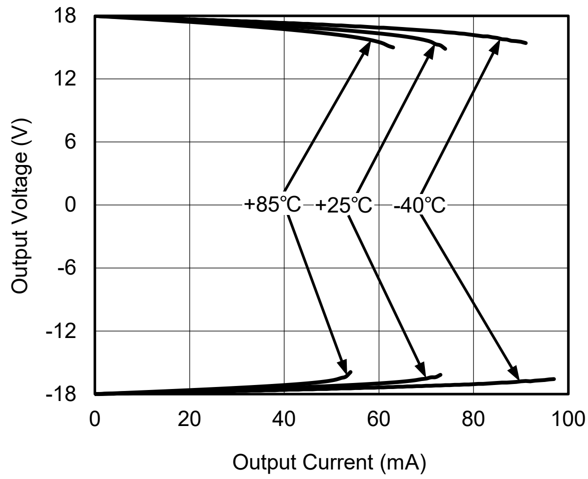
I_B and I_{OS} vs. Input Common Mode Voltage



Quiescent Current vs. Supply Voltage

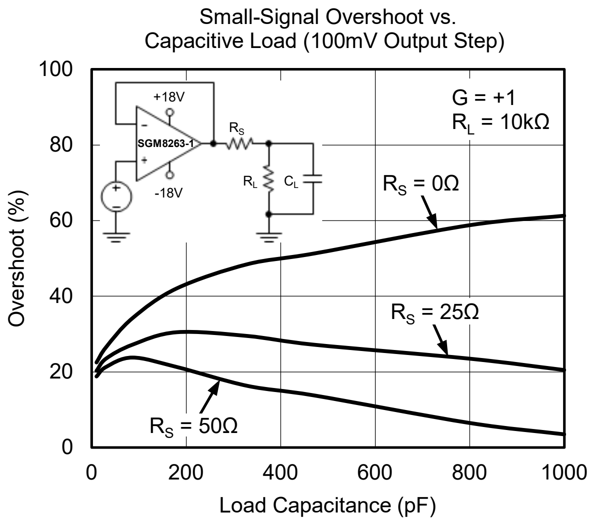


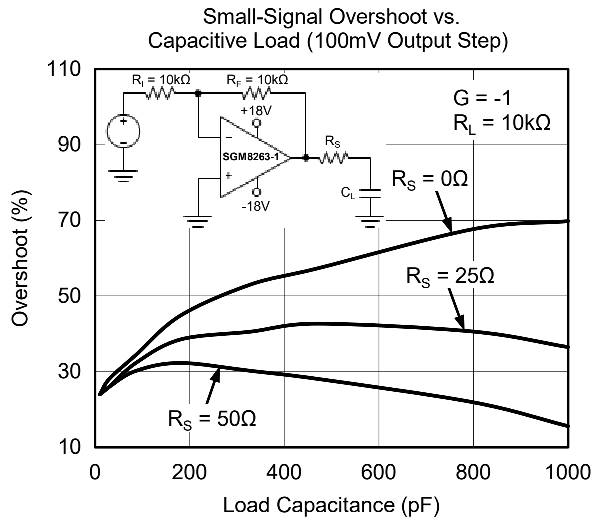
Output Voltage vs. Output Current (Maximum Supply)

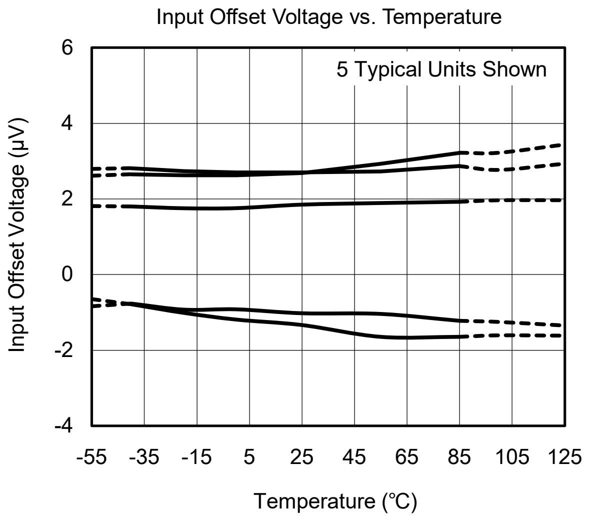


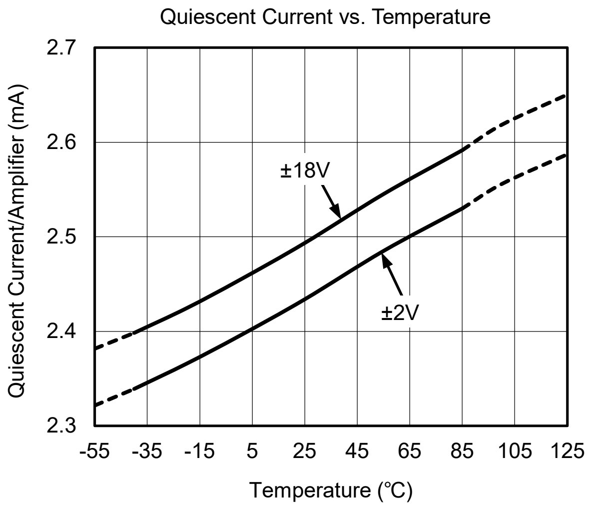
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

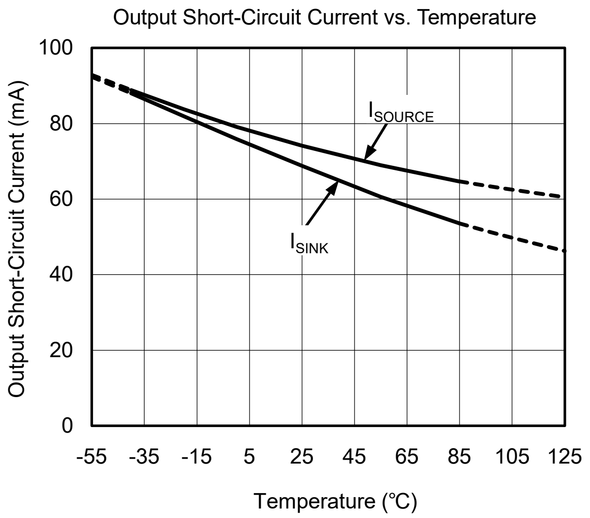
At T_A = +25℃, V_S = ±18V and R_L = 10kΩ, unless otherwise noted.

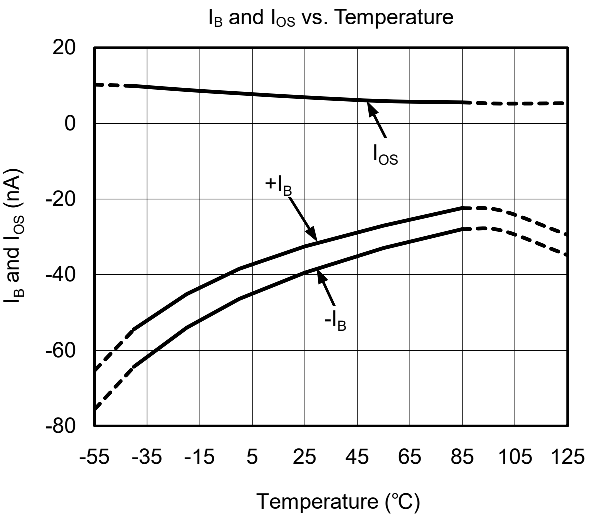








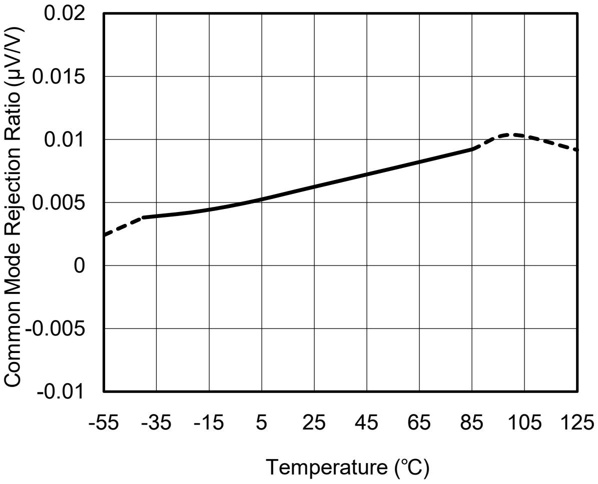




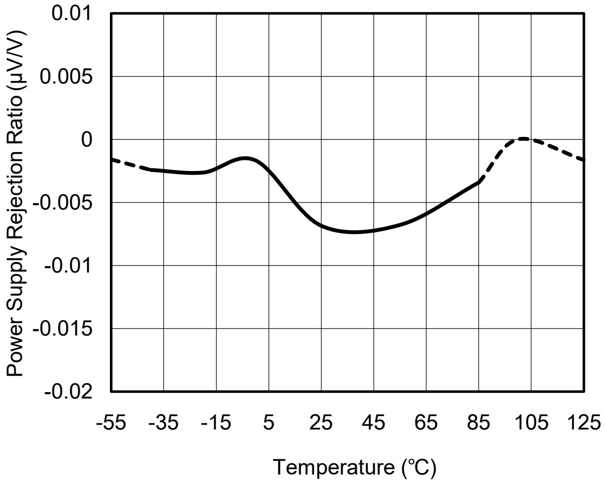
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = ±18V and R_L = 10kΩ, unless otherwise noted.

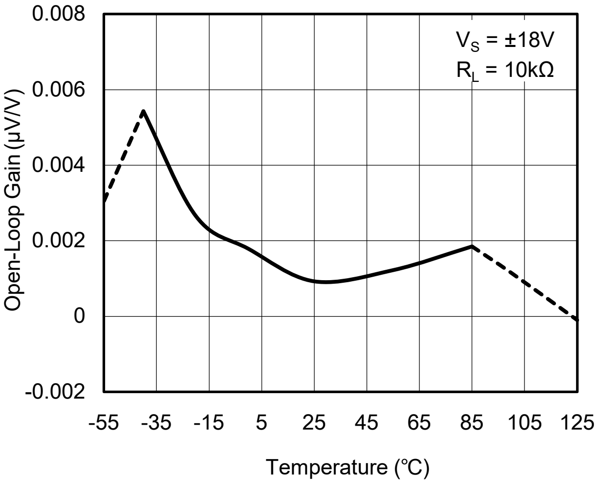
CMRR vs. Temperature



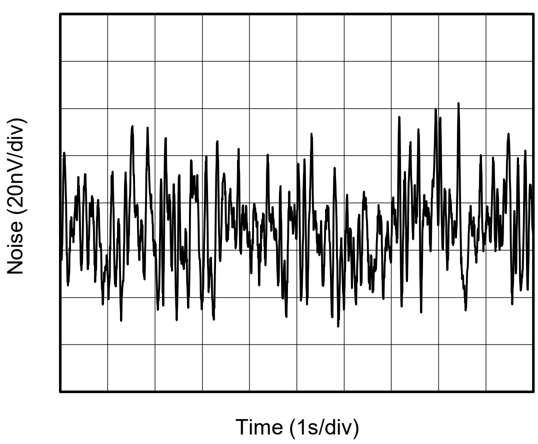
PSRR vs. Temperature



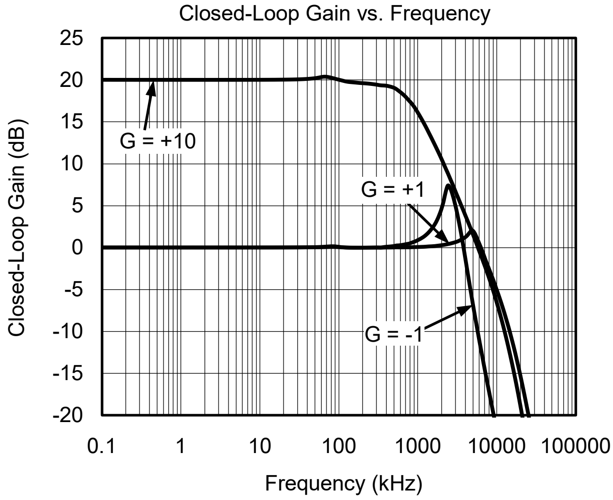
Open-Loop Gain vs. Temperature



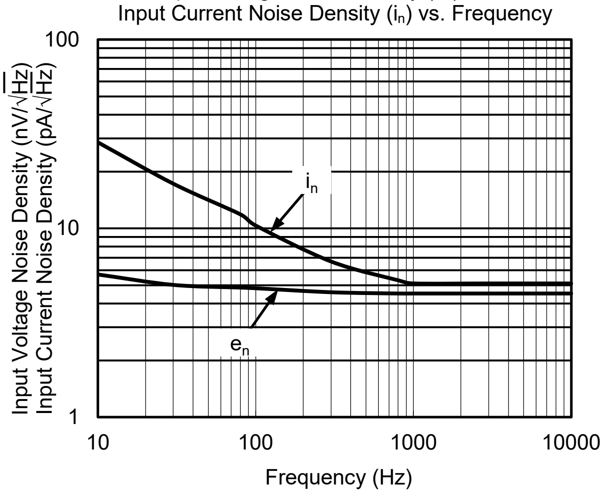
0.1Hz to 10Hz Input Voltage Noise



Closed-Loop Gain vs. Frequency

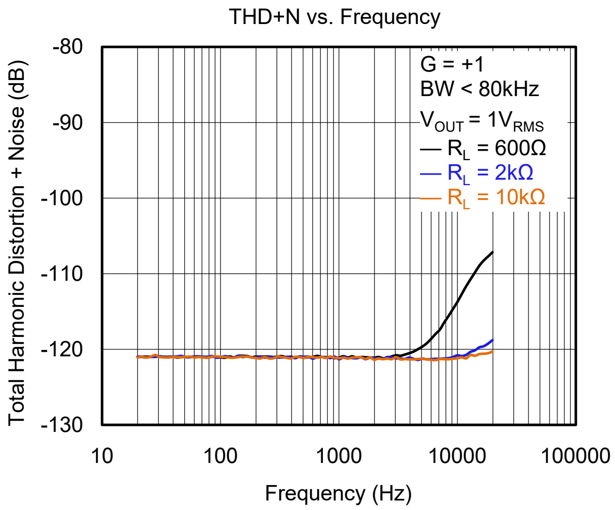


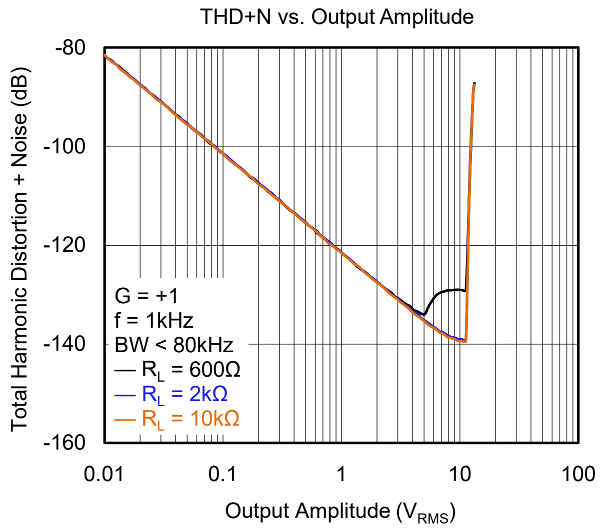
Input Voltage Noise Density (e_n) and
Input Current Noise Density (i_n) vs. Frequency

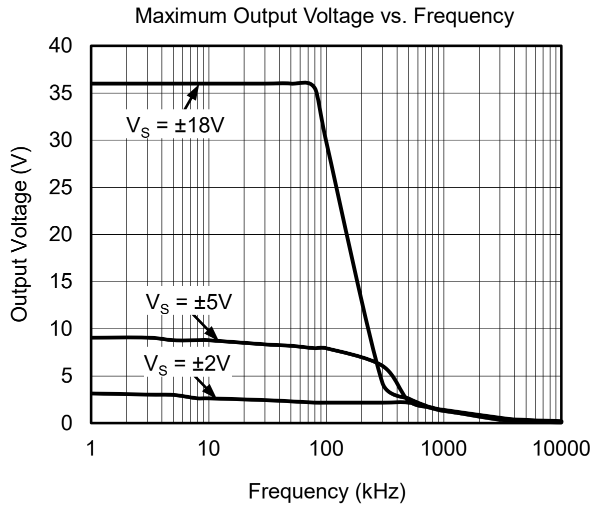


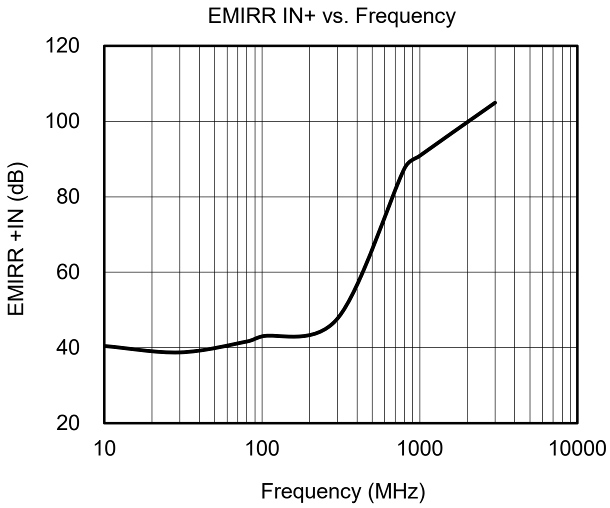
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

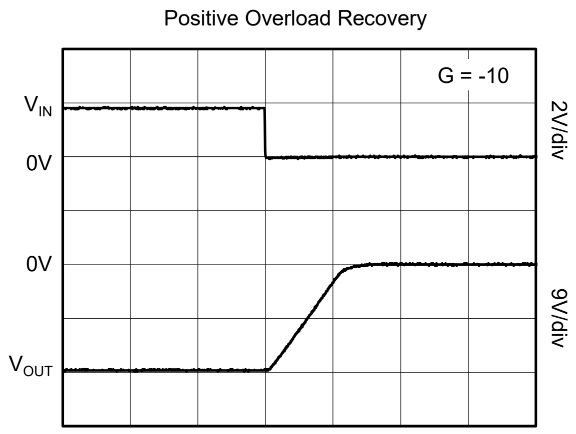
At T_A = +25℃, V_S = ±18V and R_L = 10kΩ, unless otherwise noted.

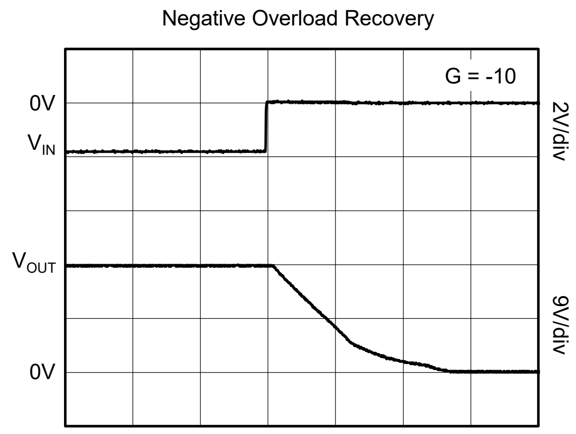






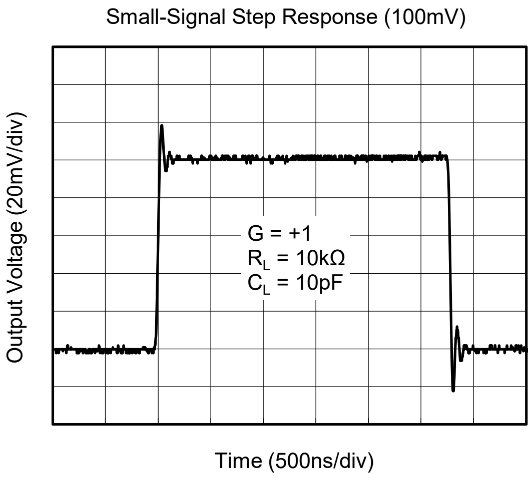


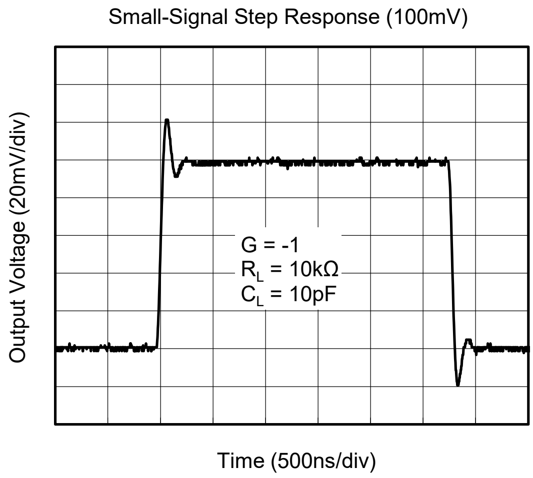


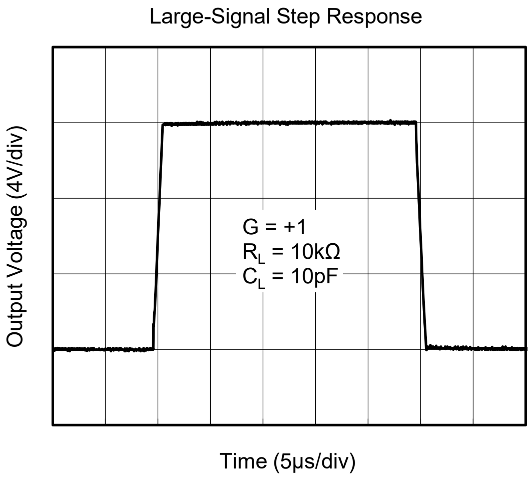


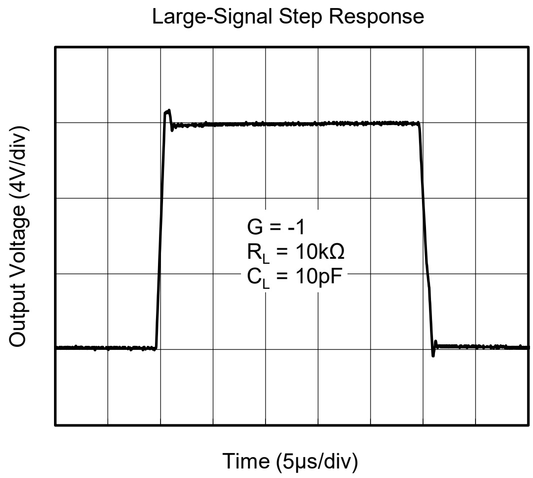
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

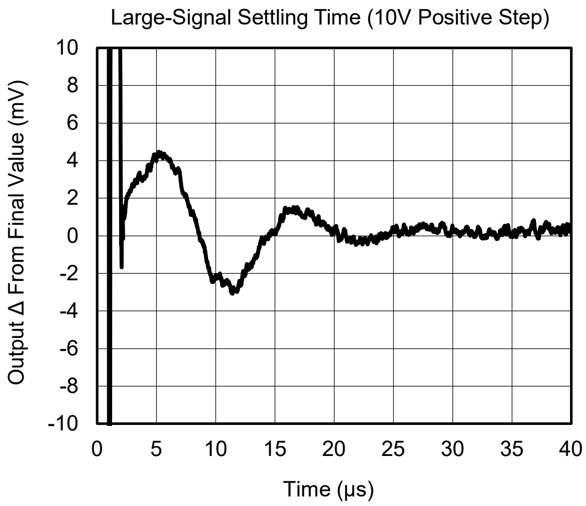
At T_A = +25℃, V_S = ±18V and R_L = 10kΩ, unless otherwise noted.

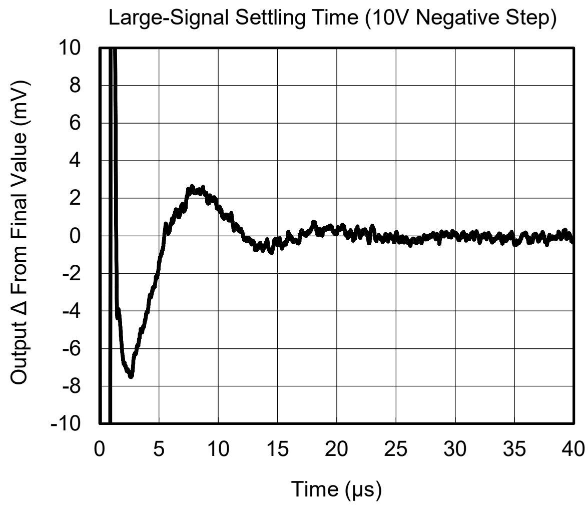






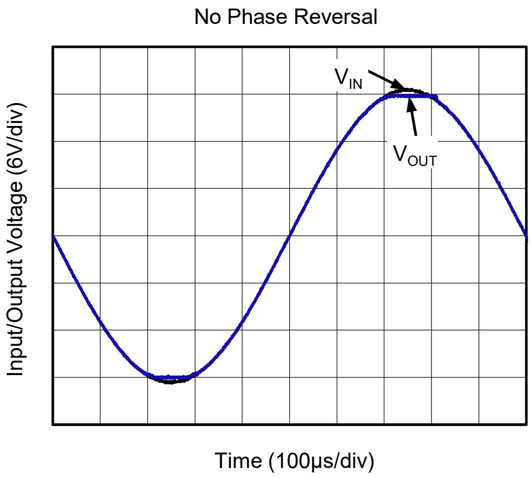


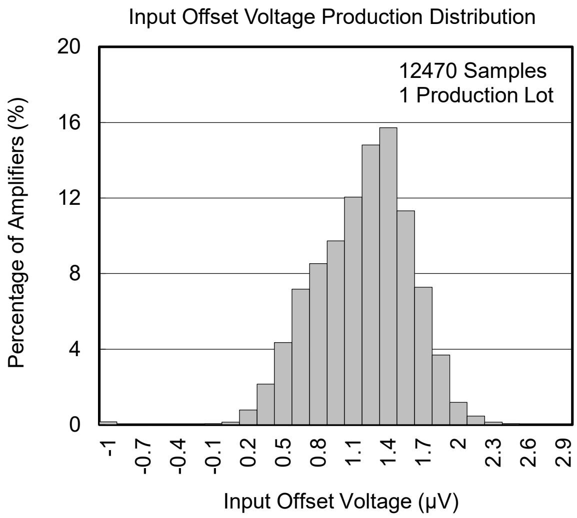


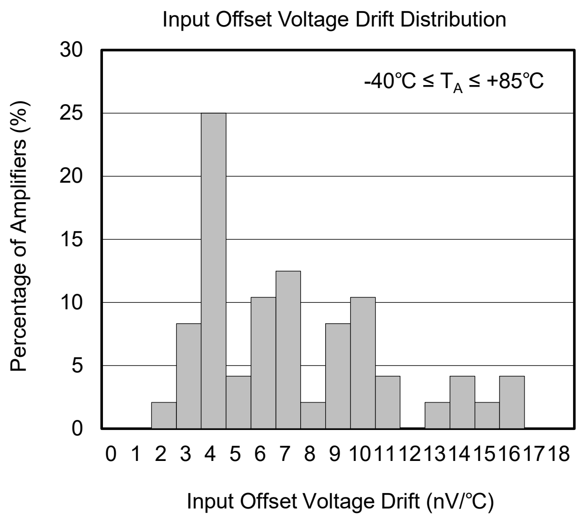


TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = ±18V and R_L = 10kΩ, unless otherwise noted.







APPLICATION INFORMATION

The SGM8263-1/2 are unity-gain stable, high precision operational amplifiers with very low noise, very low offset voltage and very low offset voltage drift; the devices are also free from output phase reversal. Applications with noisy or high-impedance power supplies require decoupling capacitors close to the device power supply pins. In most cases, 0.1μF capacitors are adequate.

Operating Voltage

The SGM8263-1/2 operational amplifiers operate from 4V to 36V or ±2V to ±18V supplies while maintaining excellent performance. However, some applications do not require equal positive and negative output voltage swing. With the SGM8263-1/2, power supply voltages do not need to be equal. For example, the positive supply could be set to 25V with the negative supply at -5V. In all cases, the input common mode voltage must be maintained within the specified range. In addition, key parameters are assured over the specified temperature range of T_A = -40℃ to +85℃.

Input Protection

The input terminals of the SGM8263-1/2 are protected from excessive differential voltage with back-to-back diodes, as Figure 1 illustrates. 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. 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 (R_I) and/or a feedback resistor (R_F) can be used to limit the signal input current. This input series resistor degrades the low-noise performance of the SGM8263-1/2 and is examined in the following Noise Performance section. Figure 1 shows an example configuration when both current-limit input and feedback resistors are used.

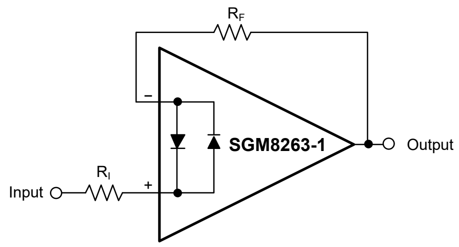


Figure 1. Input Current Limiting

Noise Performance

Equation 1 shows the total circuit noise for varying source impedances with the operational amplifier in a unity-gain configuration (Figure 2, no feedback resistor network, and therefore no additional noise contributions).

The SGM8263-1/2 (GBP = 10MHz, G = +1) are shown with total circuit noise calculated. 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 operational amplifier for a given application depends on the source impedance. For low source impedance, current noise is negligible, and voltage noise generally dominates. The low voltage noise of the SGM8263-1/2 operational amplifiers makes them good choices for use in applications where the source impedance is less than 1kΩ.

The equation 1 shows the calculation of the total circuit noise, with these parameters:

- e_n = voltage noise
- i_n = current noise
- R_S = source impedance
- k = Boltzmann's constant = 1.38 × 10^{-23}J/K
- T = temperature in degrees Kelvin (K)

$$E_O^2 = e_n^2 + (i_n R_S)^2 + 4kTR_S \quad (1)$$

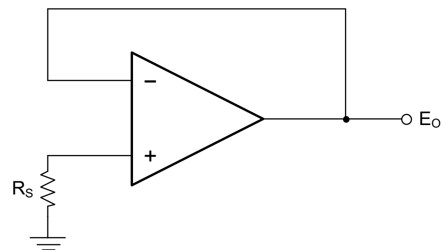


Figure 2. Unity-Gain Buffer Configuration

APPLICATION INFORMATION (continued)

Basic Noise Calculations

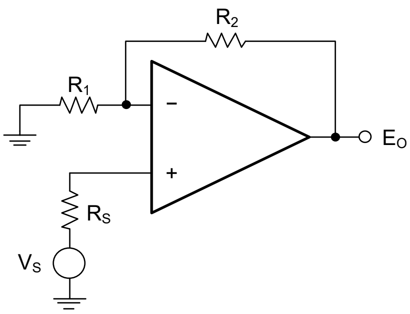
Design of low-noise operational amplifier circuits requires careful consideration of a variety of possible noise contributors: noise from the signal source, noise generated in the operational amplifier and noise from the feedback network resistors. The total noise of the circuit is the root-sum-square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

The resistive portion of the source impedance produces thermal noise proportional to the square root of the resistance. The source impedance is usually fixed; consequently, select the operational amplifier and the feedback resistors to minimize the respective contributions to the total noise.

Figure 3 illustrates both inverting and non-inverting operational amplifier circuit configurations with gain. In circuit configurations with gain, the feedback network resistors also contribute noise.

The current noise of the operational amplifier 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.

Noise in Non-Inverting Gain Configuration



Noise at the output:

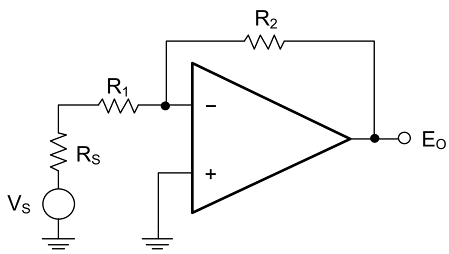
$$E_O^2 = \left[1 + \frac{R_2}{R_1}\right]^2 e_n^2 + e_1^2 + e_2^2 + (i_n R_2)^2 + e_S^2 + (i_n R_S)^2 \left[1 + \frac{R_2}{R_1}\right]^2$$

Where $e_S = \sqrt{4kTR_S} \times \left[1 + \frac{R_2}{R_1}\right]$ = thermal noise of R_S

$e_1 = \sqrt{4kTR_1} \times \left[\frac{R_2}{R_1}\right]$ = thermal noise of R_1

$e_2 = \sqrt{4kTR_2}$ = thermal noise of R_2

Noise in Inverting Gain Configuration



Noise at the output:

$$E_O^2 = \left[1 + \frac{R_2}{R_1 + R_S}\right]^2 e_n^2 + e_1^2 + e_2^2 + (i_n R_2)^2 + e_S^2$$

Where $e_S = \sqrt{4kTR_S} \times \left[\frac{R_2}{R_1 + R_S}\right]$ = thermal noise of R_S

$e_1 = \sqrt{4kTR_1} \times \left[\frac{R_2}{R_1 + R_S}\right]$ = thermal noise of R_1

$e_2 = \sqrt{4kTR_2}$ = thermal noise of R_2

NOTE: For the SGM8263-1/2 operational amplifiers at 1kHz, $e_n = 4.5nV/\sqrt{Hz}$ and $i_n = 5pA/\sqrt{Hz}$.

Figure 3. Noise Calculation in Gain Configurations

APPLICATION INFORMATION (continued)

Capacitive Loads

The dynamic characteristics of the SGM8263-1/2 have been optimized for commonly encountered gains, loads and operating conditions. The combination of low closed-loop gain and high capacitive loads decreases the phase margin of the amplifier and can lead to gain peaking or oscillations. As a result, heavier capacitive loads must be isolated from the output. The simplest way to achieve this isolation is to add a small resistor (R_S equal to 50Ω, for example) in series with the output.

Power Dissipation

SGM8263-1/2 operational amplifiers are capable of driving 2kΩ loads with a power supply voltage up to ±18V. Internal power dissipation increases when operating at high supply voltages. Copper leadframe construction used in the SGM8263-1/2 operational amplifiers improves heat dissipation compared to conventional materials. Circuit board layout can also help minimize junction temperature rise. Wide copper traces help dissipate the heat by acting as an additional heat sink. Temperature rise can be further minimized by soldering the devices to the circuit board rather than using a socket.

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 has 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.

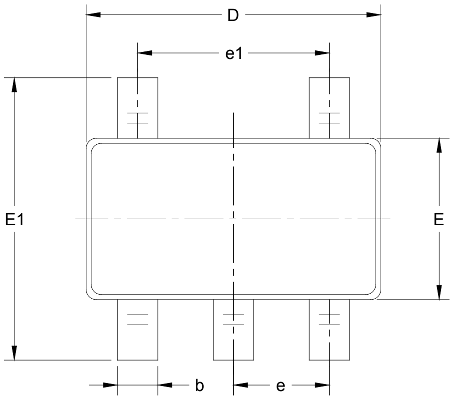
REVISION HISTORY

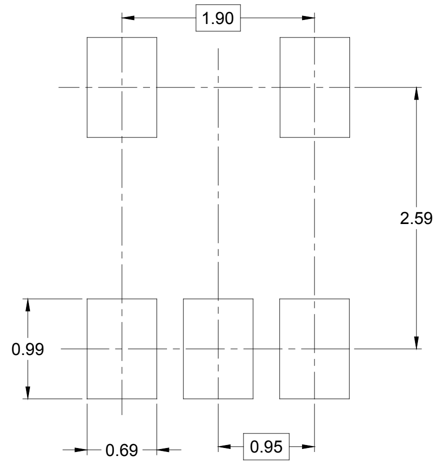
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (DECEMBER 2017) to REV.A	Page
Changed from product preview to production data	All

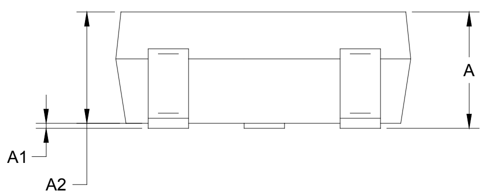
PACKAGE OUTLINE DIMENSIONS

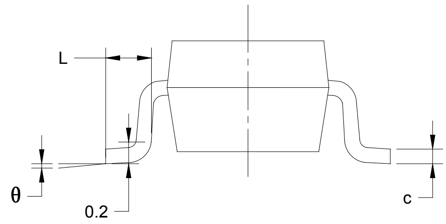
SOT-23-5





RECOMMENDED LAND PATTERN (Unit: mm)

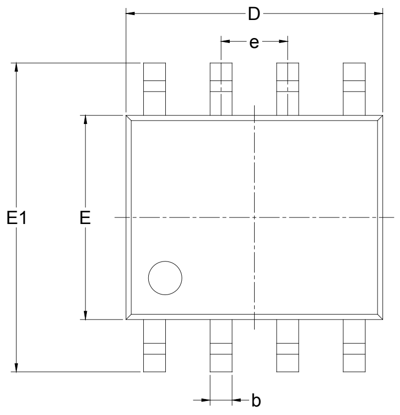


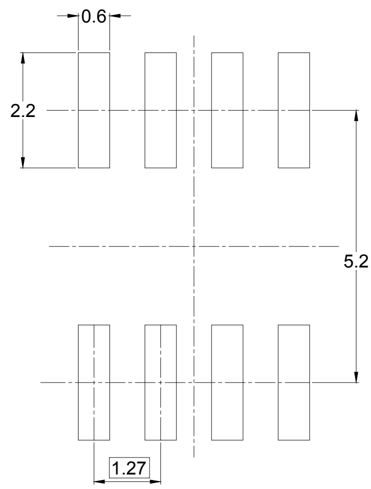


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

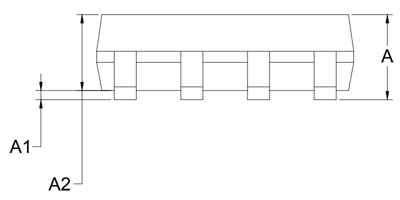
PACKAGE OUTLINE DIMENSIONS

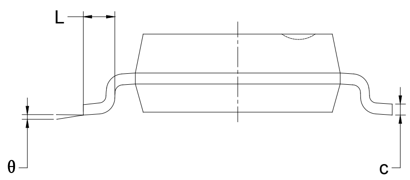
SOIC-8





RECOMMENDED LAND PATTERN (Unit: mm)

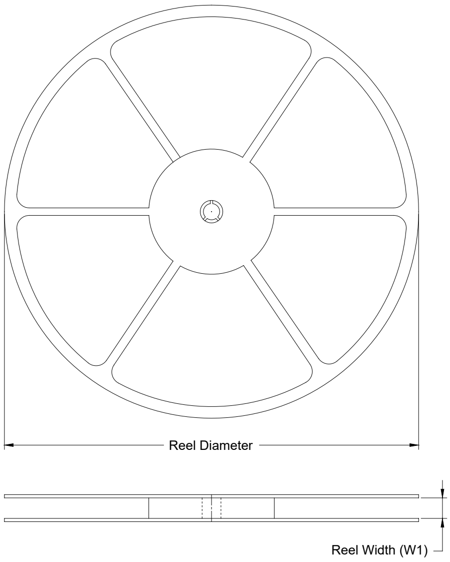




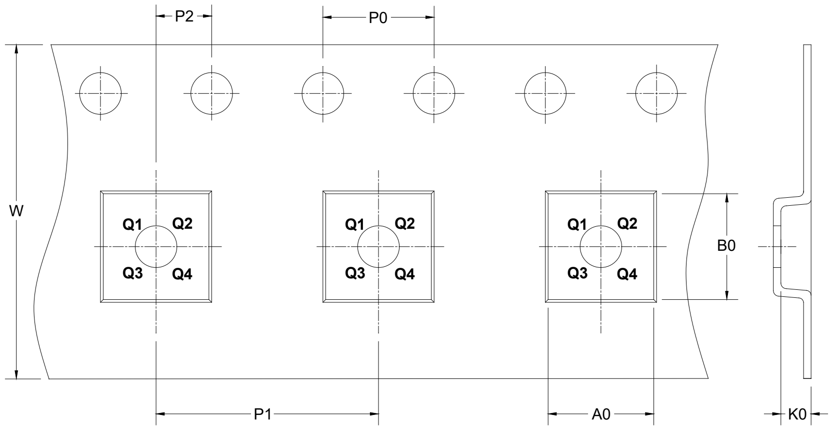
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



DIRECTION OF FEED

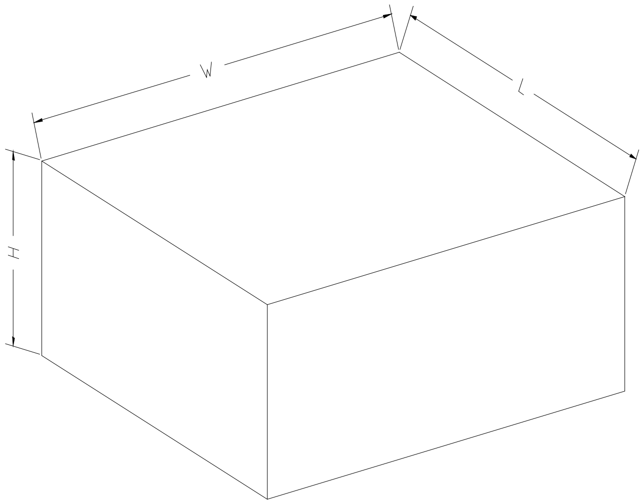
NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT-23-5	7″	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3
SOIC-8	13″	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	Q1

DD0001

CARTON BOX DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7″ (Option)	368	227	224	8
7″	442	410	224	18
13″	386	280	370	5

DD0002