SGM8607-2
1.2MHz, High Precision, Rail-to-Rail I/O, Dual CMOS Operational Amplifier in WLCSP Package

GENERAL DESCRIPTION

The SGM8607-2 integrates high precision, low noise, low voltage and low power dual CMOS operational amplifiers in a small, 9-ball WLCSP package. It can operate from 1.8V to 5.5V power supply over the -40℃ to +125℃ temperature range or operate from 1.7V to 5.5V power supply over the 0℃ to +70℃ temperature range. The SGM8607-2 supports rail-to-rail input and output operation. The input common mode voltage range is from ($-V_S$) - 0.1V to ($+V_S$) + 0.1V, and the output range is from ($-V_S$) + 0.032V to ($+V_S$) - 0.05V with 600Ω load resistor.

The SGM8607-2 features an input offset voltage of 30μV (MAX), a gain-bandwidth product of 1.2MHz, and a slew rate of 0.6V/μs.

The SGM8607-2 is available in a Green WLCSP-1.2×1.2-9B-A package. It is specified over the extended industrial temperature range (-40℃ to +125℃).

APPLICATIONS

Sensors
Audio
Active Filters
A/D Converters
Communications
Test Equipment
Cellular and Cordless Phones
Laptops and PDAs
Photodiode Amplification

FEATURES

- **Low Input Offset Voltage: 30μV (MAX)**
- **Low Input Bias Current: 70pA (TYP)**
- **Input Voltage Noise Density: 27nV/$\sqrt{Hz}$ at 10kHz**
- **Gain-Bandwidth Product: 1.2MHz**
- **Gain = +20 Stable for C_L = 1nF**
  Unity-Gain Stable for C_L = 100pF
- **Slew Rate: 0.6V/μs**
- **Settling Time to 0.1% with 2V Step: 1μs**
- **Overload Recovery Time: 0.5μs**
- **Rail-to-Rail Input and Output**
- **Power Supply Voltage:**
  - **Low 1.8V Supply Rail over the -40℃ to +125℃ Range**
  - **Low 1.7V Supply Rail over the 0℃ to +70℃ Range**
  - **High Supply Voltage: 5.5V**
- **Input Signal Range: ($-V_S$) - 0.1V to ($+V_S$) + 0.1V**
- **Low Power:**
  - **140μA (TYP)**
  - **0.6μA (MAX) Supply Current in Shutdown**
- **Available in a Green WLCSP-1.2×1.2-9B-A Package**

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8607-2	WLCSP-1.2×1.2-9B-A	-40℃ to +125℃	SGM8607-2XG/TR	01I XXXX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XXXX = Date Code, Trace Code and Vendor Code.

YYY — Serial Number
XXXX
Vendor Code
Trace Code
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 $-V_S$ 6.0V
Input Common Mode Voltage Range
.... $(-V_S)$ - 0.3V to $(+V_S)$ + 0.3V
Junction Temperature .... +150℃
Storage Temperature Range .... -65℃ to +150℃
Lead Temperature (Soldering, 10s) .... +260℃
ESD Susceptibility
HBM 4000V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Operating Temperature Range .... -40℃ to +125℃

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

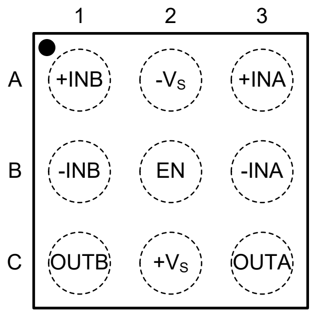
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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 CONFIGURATION

(TOP VIEW)



WLCSP-1.2×1.2-9B-A

PIN DESCRIPTION

PIN	NAME	FUNCTION
A1	+INB	Non-Inverting Input of Amplifier B.
A2	$-V_S$	Negative Power Supply.
A3	+INA	Non-Inverting Input of Amplifier A.
B1	-INB	Inverting Input of Amplifier B.
B2	EN	Active High Enable Input. When EN = High, the SGM8607-2 is in active status. When EN = Low, the SGM8607-2 is in shutdown status.
B3	-INA	Inverting Input of Amplifier A.
C1	OUTB	Output of Amplifier B.
C2	$+V_S$	Positive Power Supply.
C3	OUTA	Output of Amplifier A.

ELECTRICAL CHARACTERISTICS

(V_S = 3.3V, V_{CM} = V_S/2, V_{EN} = +V_S, Full = -40℃ to +125℃, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Input Characteristics						
Input Offset Voltage (V_{OS})	V_S = 5V	+25℃		5	30	μV
		Full			90	
Input Offset Voltage Drift ($\Delta V_{OS}/\Delta T$)		Full		0.12	0.6	μV/℃
Input Bias Current (I_B)	V_S = 1.8V to 5.5V	+25℃		70	2000	pA
		Full			9	nA
Input Offset Current (I_{OS})	V_S = 1.8V to 5.5V	+25℃		140		pA
Input Common Mode Voltage Range (V_{CM})		Full	(-V_S) - 0.1		(+V_S) + 0.1	V
Common Mode Rejection Ratio (CMRR)	(-V_S) - 0.1V ≤ V_{CM} ≤ (+V_S) + 0.1V	+25℃	98	114		dB
		Full	95			
Open-Loop Voltage Gain (A_{OL})	(-V_S) + 0.25V < V_{OUT} < (+V_S) - 0.25V, R_L = 600Ω	+25℃	101	114		dB
		Full	98			
	(-V_S) + 0.1V < V_{OUT} < (+V_S) - 0.1V, R_L = 10kΩ	+25℃	102	120		
		Full	99			
Input Capacitance (C_{IN})		+25℃		30		pF
Output Characteristics						
Output Voltage Low	V_{OL} = V_{OUT} - (-V_S), R_L = 600Ω	+25℃		32	50	mV
		Full			70	
	V_{OL} = V_{OUT} - (-V_S), R_L = 10kΩ	+25℃		2	5	
		Full			7	
Output Voltage High	V_{OH} = (+V_S) - V_{OUT}, R_L = 600Ω	+25℃		50	65	mV
		Full			92	
	V_{OH} = (+V_S) - V_{OUT}, R_L = 10kΩ	+25℃		3	7	
		Full			9	
Output Short-Current Limited (I_{LIM})	Short to +V_S or -V_S	+25℃		28		mA
Power Supply						
Operating Voltage Range (V_S)		Full	1.8		5.5	V
		+25℃	1.7		5.5	
Power Supply Rejection Ratio (PSRR)	V_S = 1.8V to 5.5V, V_{CM} = (-V_S) + 0.5V	+25℃	100	124		dB
		Full	97			
Quiescent Current (I_Q)	I_{OUT} = 0A	+25℃		140	195	μA
		Full			235	
Shutdown Supply Current (I_{SHDN})	I_{OUT} = 0A, V_{EN} = -V_S	+25℃			0.6	μA

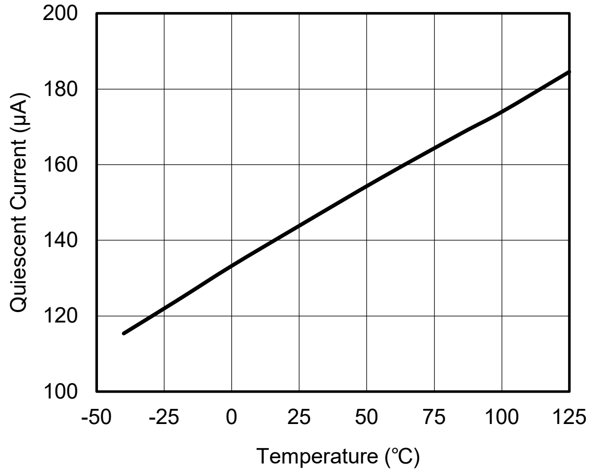
ELECTRICAL CHARACTERISTICS (continued)

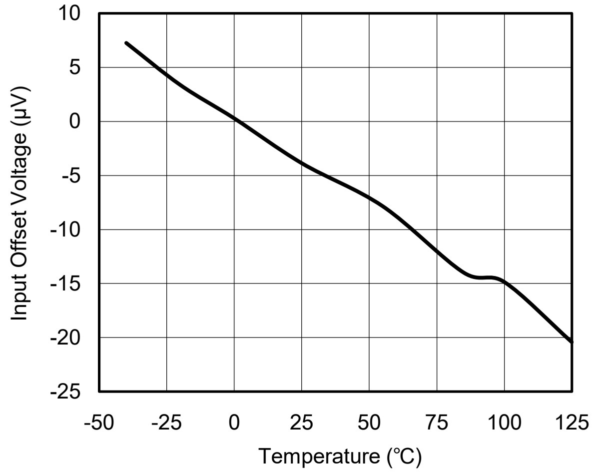
(V_S = 3.3V, V_{CM} = V_S/2, V_{EN} = +V_S, Full = -40℃ to +125℃, typical values are at T_A = +25℃, unless otherwise noted.)

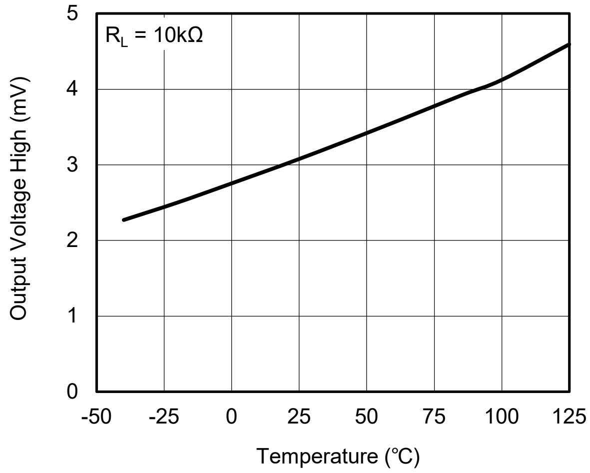
PARAMETER	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Dynamic Performance						
Gain-Bandwidth Product (GBP)		+25℃		1.2		MHz
Phase Margin (φ_O)	G = +20, R_L = 10kΩ, C_L = 1nF	+25℃		56		°
	G = +1, R_L = 10kΩ, C_L = 100pF	+25℃		55		
Slew Rate (SR)	G = +1, 2V output step	+25℃		0.6		V/μs
Settling Time to 0.1% (t_S)	G = +1, 2V output step	+25℃		1		μs
Overload Recovery Time (ORT)	V_{IN} × G = V_S	+25℃		0.5		μs
Noise Performance						
Input Voltage Noise	f = 0.1Hz to 10Hz	+25℃		0.4		μV_{P-P}
Input Voltage Noise Density (e_n)	f = 10kHz	Full		27	55	$nV/\sqrt{Hz}$
EN Control						
Input Voltage Low (V_{IL})	+V_S = 1.8V to 5.5V, -V_S = GND	Full			0.4	V
Input Voltage High (V_{IH})	+V_S = 1.8V to 5.5V, -V_S = GND	Full	1.7			V
Turn-On Time from Shutdown (t_{SHDN})		+25℃		275	420	μs
		Full			600	
Power-Up Time (t_{ON})		Full		0.6	1.2	ms

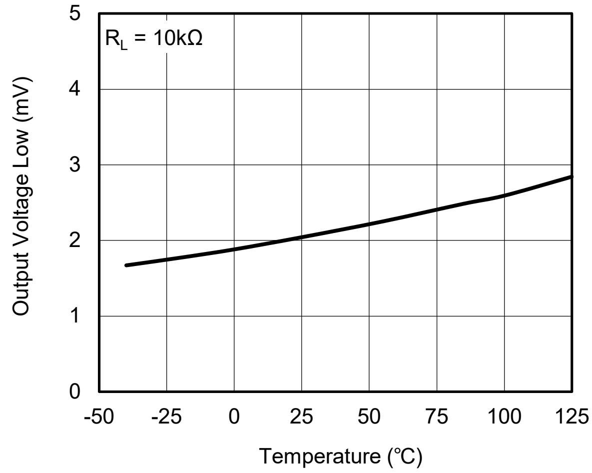
TYPICAL PERFORMANCE CHARACTERISTICS

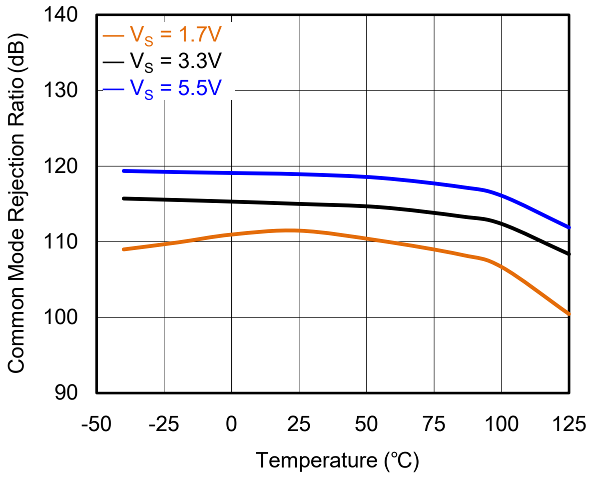
At T_A = +25℃, V_S = 3.3V, V_{CM} = V_S/2, V_{EN} = +V_S, unless otherwise noted.

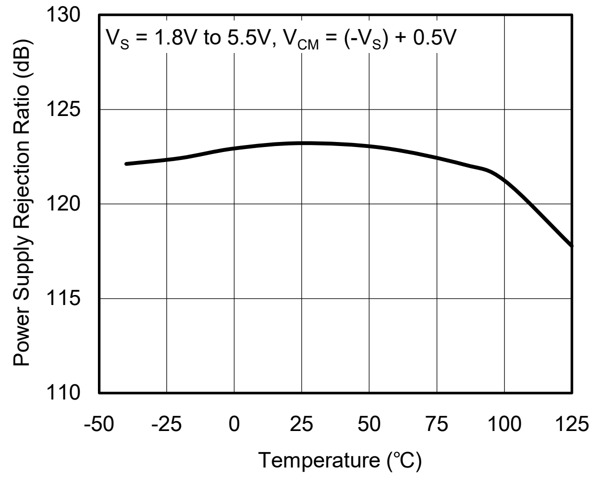








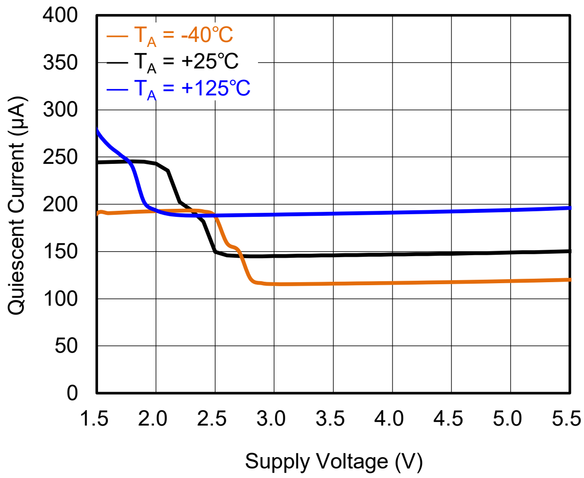




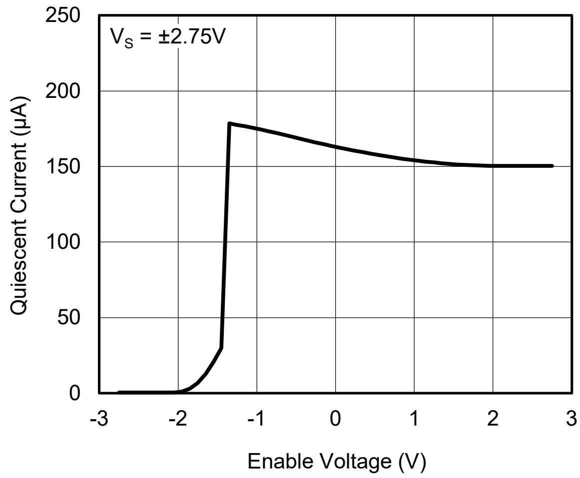
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = 3.3V, V_{CM} = V_S/2, V_{EN} = +V_S, unless otherwise noted.

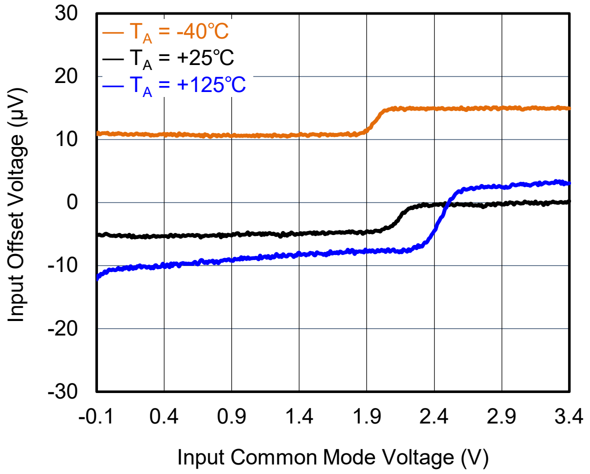
Quiescent Current vs. Supply Voltage



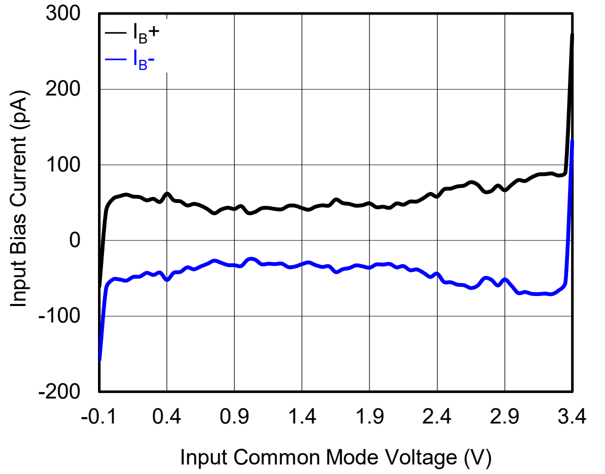
Quiescent Current vs. Enable Voltage



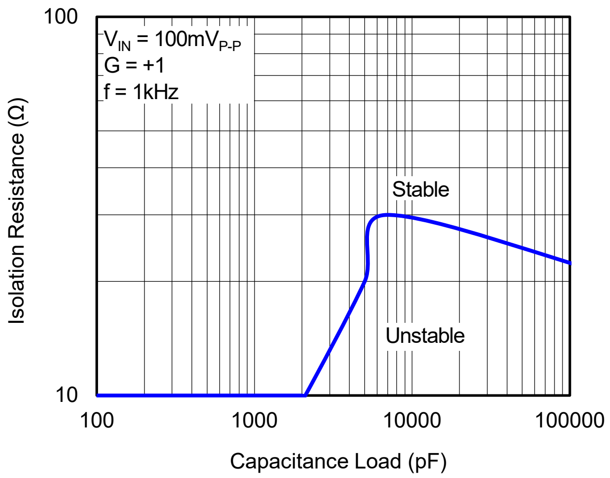
Input Offset Voltage vs. Input Common Mode Voltage



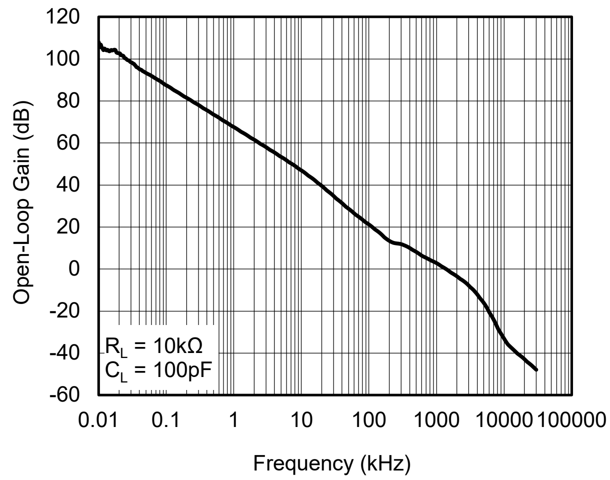
Input Bias Current vs. Input Common Mode Voltage



Stability vs. Capacitive and Resistive Load



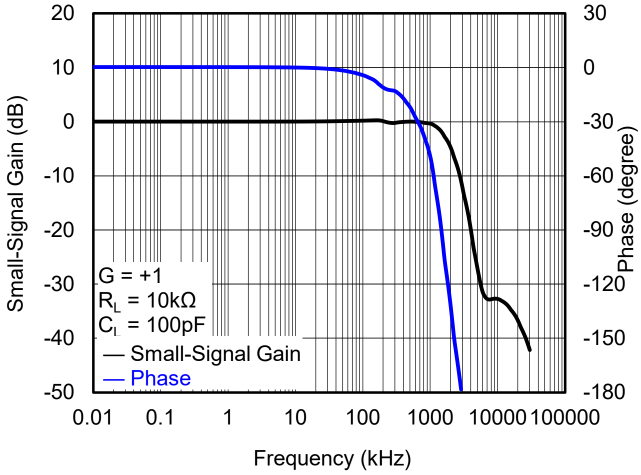
Open-Loop Voltage Gain vs. Frequency



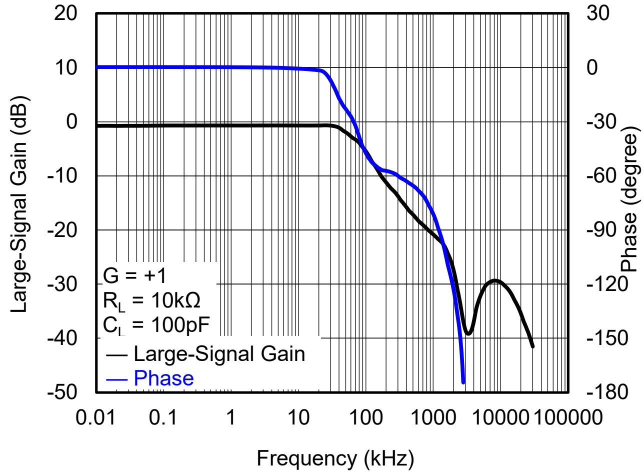
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = 3.3V, unless otherwise noted.

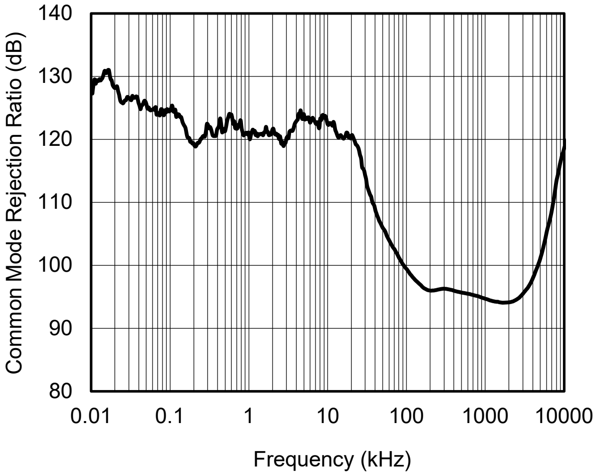
Small-Signal Voltage Gain and Phase vs. Frequency



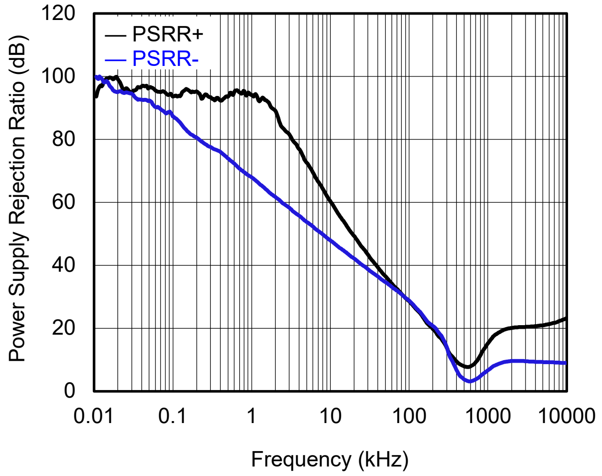
Large-Signal Voltage Gain and Phase vs. Frequency



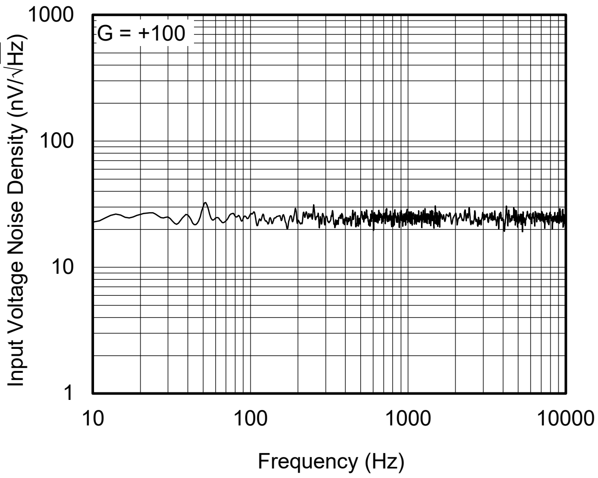
CMRR vs. Frequency



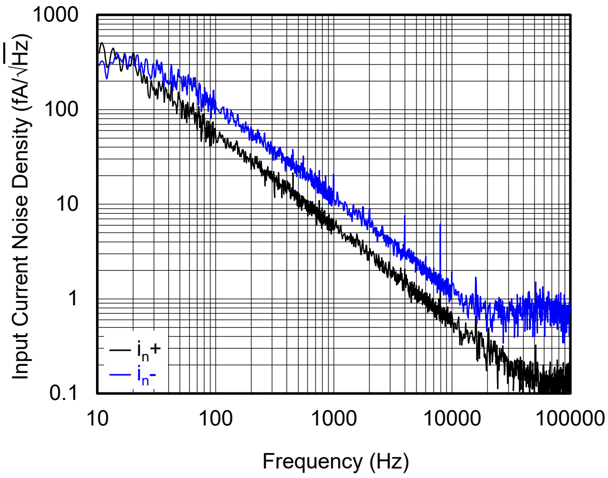
PSRR vs. Frequency



Input Voltage Noise Density vs. Frequency



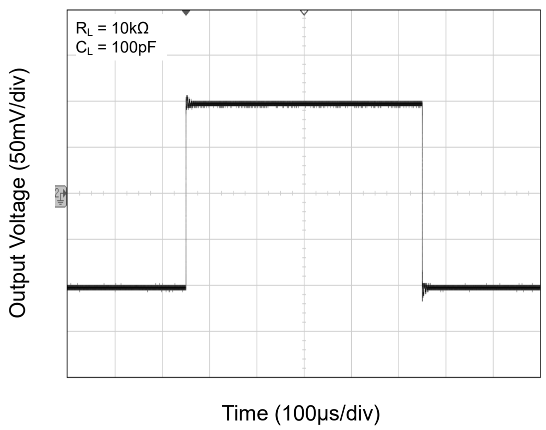
Input Current Noise Density vs. Frequency



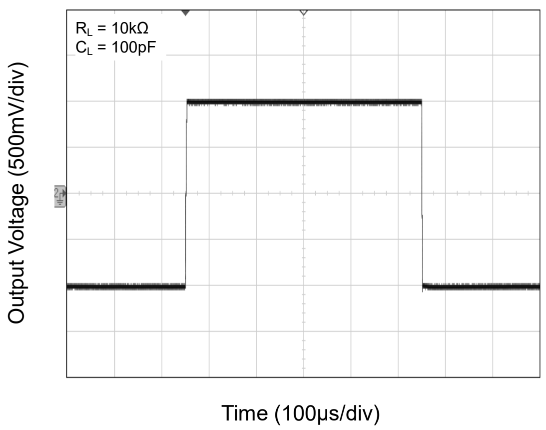
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = 3.3V, unless otherwise noted.

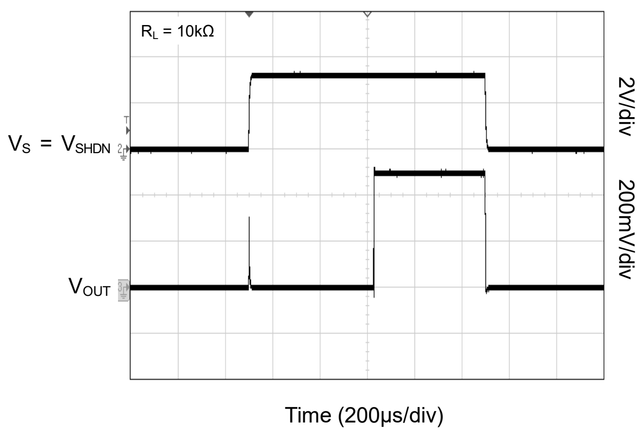
Small-Signal Step Response



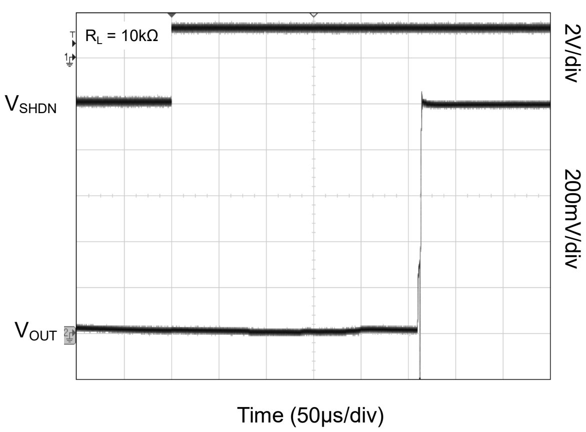
Large-Signal Step Response



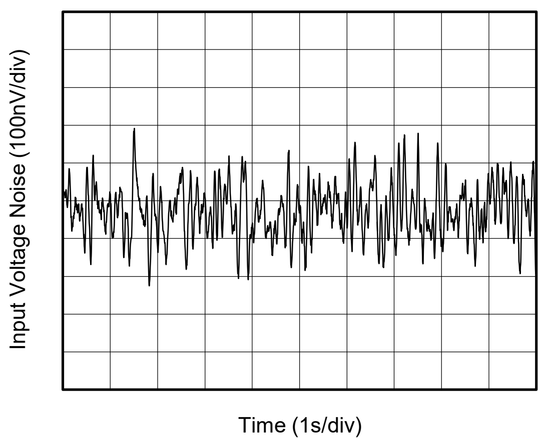
Power-Up Time



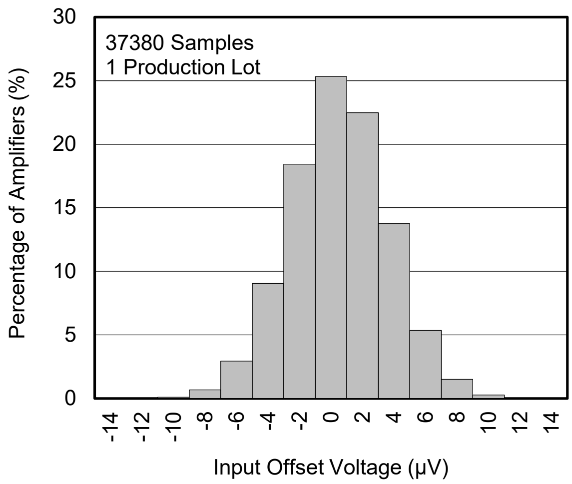
Shutdown Enable Response



0.1Hz to 10Hz Input Voltage Noise

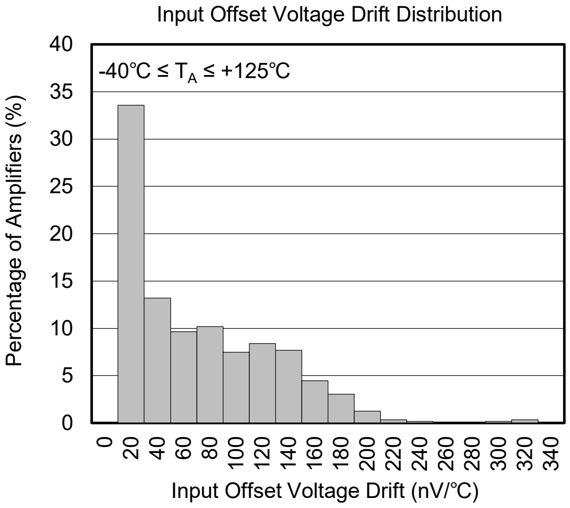


Input Offset Voltage Production Distribution



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = 3.3V, unless otherwise noted.



APPLICATION INFORMATION

Rail-to-Rail Input

The input common mode voltage range of the SGM8607-2 extends 100mV beyond the supply rails for the full supply voltage range. In Figure 1, the ESD diodes between the inputs and the power supply rails will clamp the input voltage not to exceed the rails.

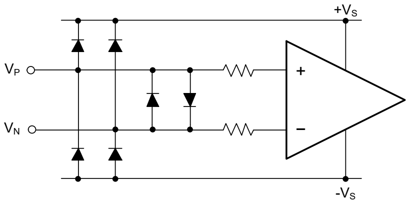


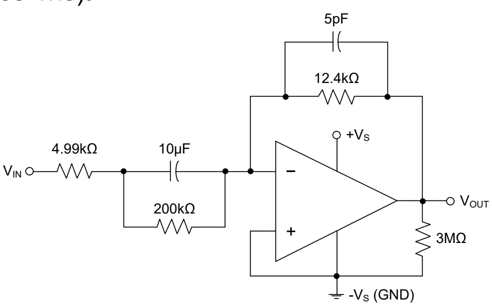
Figure 1. Input Equivalent Circuit

Input Current-Limit Protection

For ESD diode clamping protection, when the current flowing through ESD diode exceeds the maximum rating value, the ESD diode and amplifier will be damaged, so current-limit protection will be added in some applications. One resistor is selected to limit the current not to exceed the maximum rating value. In Figure 2, a series input resistor is used to limit the input current, but the drawback of this current-limit resistor is that it contributes thermal noise at the amplifier input. If this resistor must be added, its value must be selected as small as possible.

In addition, a clamping circuit on its inputs can sink current (up to 20mA) when the input is ($+V_S$) + 0.3V. This is for protecting from a worst V_{IN} short-circuit condition, and any alternate would need to have some sort of clamping behavior on its inputs. But in the shutdown mode, the clamping circuit does not work.

In the circuit (Figure 2), the operational amplifier inputs can handle a V_{IN} pulse (20V pulses width 1μs, rise and fall times 1ns).



NOTE: A current-limit resistor is required if the input voltage exceeds the supply rails by ≥ 0.3V.

Figure 2. Input Current-Limit Protection

Rail-to-Rail Output

The SGM8607-2 supports rail-to-rail output operation. In single power supply application, for example, when $+V_S$ = 3.3V, $-V_S$ = GND, 600Ω load resistor is tied from OUT pin to ground, the typical output swing range is from 0.032V to 3.25V.

Driving Capacitive Loads

The SGM8607-2 can directly drive a 1nF capacitor at Gain = +20 or a 100pF capacitor at Gain = +1 without oscillation. If greater capacitive load must be driven in application, the circuit in Figure 3 can be used. In this circuit, the IR drop voltage generated by R_{ISO} is compensated by feedback loop.

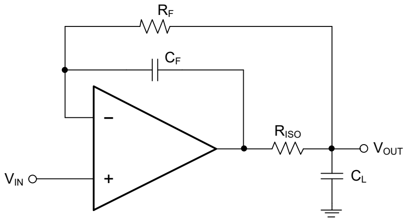


Figure 3. Circuit to Drive Heavy Capacitive Load

Power Supply Decoupling and Layout

A clean and low noise power supply is very important in amplifier circuit design. Besides of input signal noise, the power supply is one of important source of noise to the amplifiers through $+V_S$ and $-V_S$ pins. Power supply bypassing is an effective method to clear up the noise at power supply, and the low impedance path to ground of decoupling capacitor will bypass the noise to GND. In application, 10μF ceramic capacitor paralleled with 0.1μF or 0.01μF ceramic capacitor is used in Figure 4. The ceramic capacitors should be placed as close as possible to $+V_S$ and $-V_S$ power supply pins.

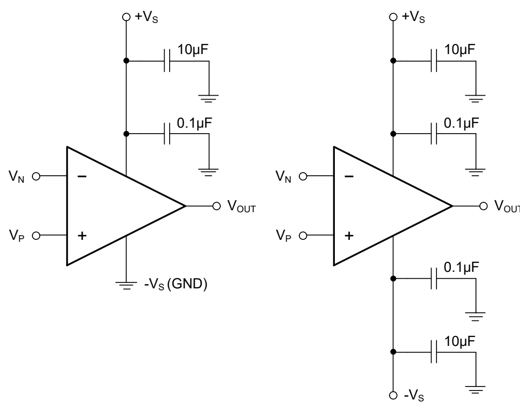


Figure 4. Amplifier Power Supply Bypassing

APPLICATION INFORMATION (continued)

Grounding

In low speed application, one node grounding technique is the simplest and most effective method to eliminate the noise generated by grounding. In high speed application, the general method to eliminate noise is to use a complete ground plane technique, and the whole ground plane will help distribute heat and reduce EMI noise pickup.

Reduce Input-to-Output Coupling

To reduce the input-to-output coupling, the input traces must be placed as far away from the power supply or output traces as possible. The sensitive trace must not be placed in parallel with the noisy trace in same layer. They must be placed perpendicularly in different layers to reduce the crosstalk. These PCB layout techniques will help to reduce unwanted positive feedback and noise.

Typical Application Circuits

Difference Amplifier

The circuit in Figure 5 is a design example of classical difference amplifier. If $R_4/R_3 = R_2/R_1$, then $V_{OUT} = (V_P - V_N) \times R_2/R_1 + V_{REF}$.

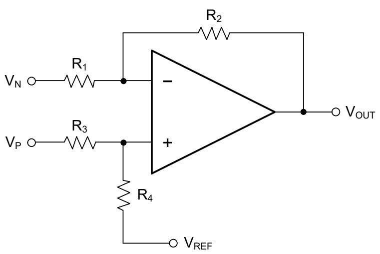


Figure 5. Difference Amplifier

High Input Impedance Difference Amplifier

The circuit in Figure 6 is a design example of high input impedance difference amplifier. The added amplifiers at the input are used to increase the input impedance and eliminate drawback of low input impedance in Figure 5.

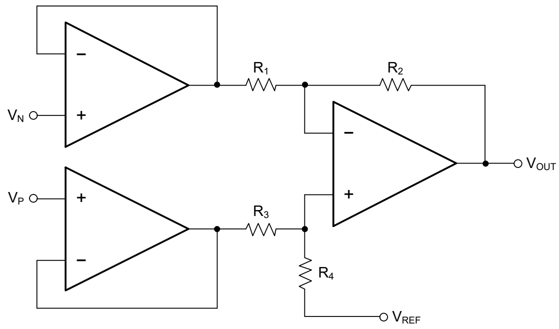


Figure 6. High Input Impedance Difference Amplifier

Active Low-Pass Filter

The circuit in Figure 7 is a design example of active low-pass filter, the DC gain is equal to $-R_2/R_1$ and the -3dB corner frequency is equal to $1/2\pi R_2C$. In this design, the filter bandwidth must be less than the bandwidth of the amplifier, and the resistor values must be selected as low as possible to reduce ringing or oscillation generated by the parasitic parameters in PCB layout.

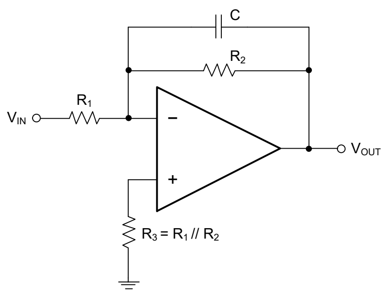


Figure 7. Active Low-Pass Filter

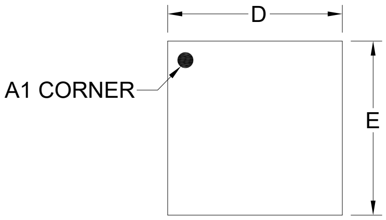
REVISION HISTORY

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

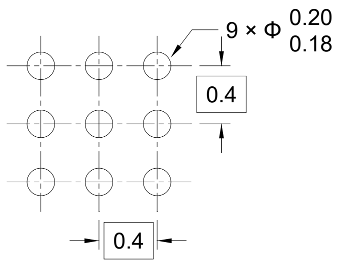
Changes from Original (DECEMBER 2023) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

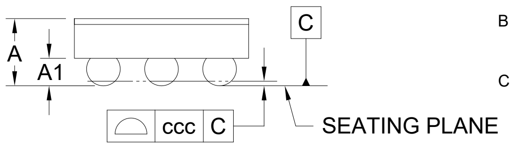
WLCSP-1.2×1.2-9B-A



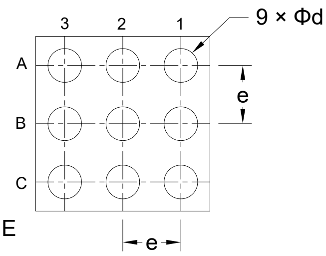
TOP VIEW



RECOMMENDED LAND PATTERN (Unit: mm)



SIDE VIEW



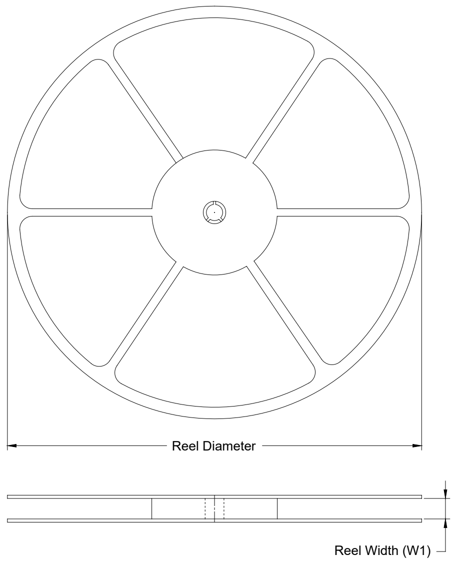
BOTTOM VIEW

Symbol	Dimensions In Millimeters		
	MIN	MOD	MAX
A	-	-	0.500
A1	0.169	-	0.209
D	1.170	-	1.230
E	1.170	-	1.230
d	0.202	-	0.262
e	0.400 BSC		
ccc	0.050		

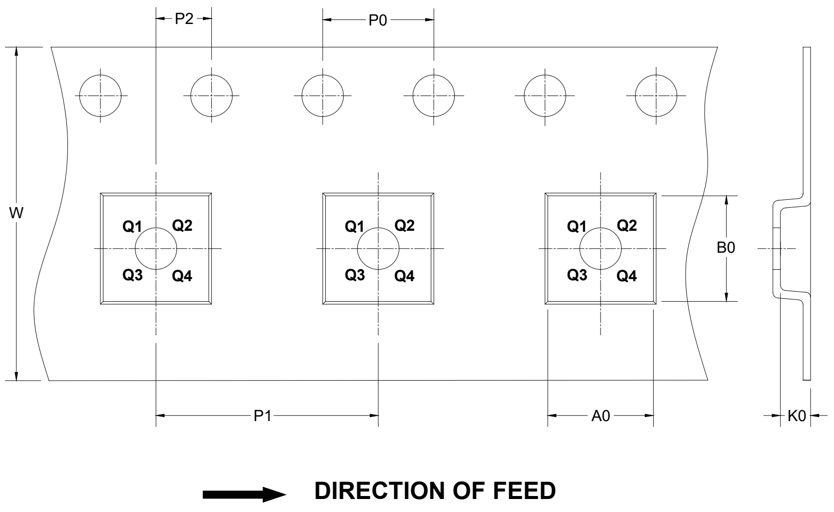
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



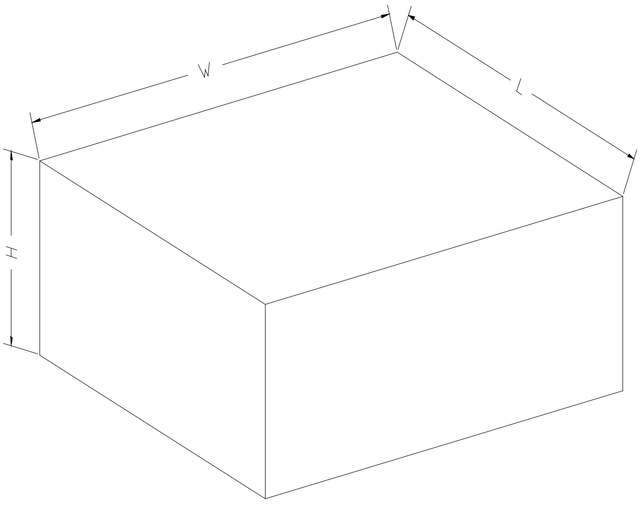
NOTE: The picture is only for reference. Please make the object as the standard.

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
WLCSP-1.2×1.2-9B-A	7″	9.2	1.31	1.31	0.58	4.0	4.0	2.0	8.0	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

DD0002