SGM8261-5
Bipolar-Input, High Performance, Ultra-Low Noise HiFi Audio Headset Driver

GENERAL DESCRIPTION

The SGM8261-5 is a dual, bipolar-input, low noise operational amplifier optimized for high voltage systems. The device operates from 3.6V to 36V single supply or from ±3.6V to ±18V dual power supplies, while consuming 4.1mA quiescent current per amplifier.

The SGM8261-5 has impressive dynamic characteristics with various loads. The rail-to-rail output voltage range is from $(-V_S)$ + 0.15V to $(+V_S)$ - 0.15V when 2kΩ load resistor is tied from OUT pin to $V_S/2$. This results in large headroom and wide dynamic range. The SGM8261-5 is unity-gain stable and offers a ±110mA high output current. It features 1.6nV/$\sqrt{Hz}$ ultra-low noise at 1kHz with 0.00002% distortion.

The SGM8261-5 is available in Green MSOP-10 and TDFN-3×3-10L packages. It operates over an ambient temperature range of -40℃ to +85℃.

FEATURES

- **Excellent Sound Quality**
- **Ultra-Low Input Voltage Noise: 1.6nV/$\sqrt{Hz}$ at 1kHz**
- **Ultra-Low Distortion: 0.00002% at 1kHz**
- **Low Offset Voltage: ±350μV (MAX)**
- **Unity-Gain Stable**
- **Gain-Bandwidth Product: 16MHz (G = +1)**
- **High Slew Rate: 16V/μs**
- **High Open-Loop Gain: 150dB**
- **Rail-to-Rail Output**
- **Support Single or Dual Power Supplies: 3.6V to 36V or ±3.6V to ±18V**
- **Low Quiescent Current: 4.1mA/Amplifier**
- **-40℃ to +85℃ Operating Temperature Range**
- **Available in Green MSOP-10 and TDFN-3×3-10L Packages**

APPLICATIONS

Professional Audio Instrument

High-End A/V Receiving Machines

Analog and Digital Mixing Control Boards

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8261-5	MSOP-10	-40℃ to +85℃	SGM8261-5YMS10G/TR	SGM82615 YMS10 XXXXX	Tape and Reel, 4000
	TDFN-3×3-10L	-40℃ to +85℃	SGM8261-5YTD10G/TR	SGM 82615D XXXXX	Tape and Reel, 4000

MARKING INFORMATION

NOTE: XXXXX = Date Code and Vendor Code.

XXXXX
- Vendor Code
- Date Code - Week
- 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
EN to GND..-0.3V to 5.5V
Input Current (All pins except power supply pins)...... ±10mA
Output Short-Circuit Current .... ±180mA
Junction Temperature...+150℃
Storage Temperature Range ....-65℃ to +150℃
Lead Temperature (Soldering, 10s)............................+260℃
ESD Susceptibility
HBM...8000V
MM...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

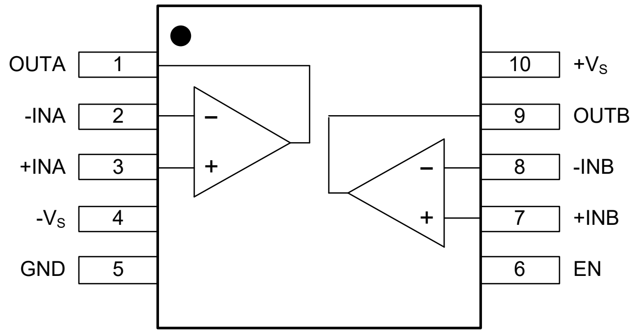
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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

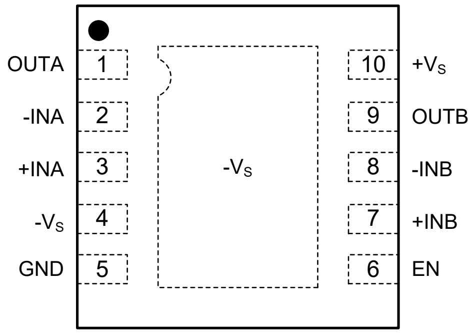
PIN CONFIGURATIONS

(TOP VIEW)



MSOP-10

(TOP VIEW)



TDFN-3×3-10L

NOTE: For TDFN-3×3-10L package, connect thermal die pad to -V_S. Connect it to -V_S plane to maximize thermal performance.

ELECTRICAL CHARACTERISTICS

(At T_A = +25℃, V_S = ±5V to ±18V, GND = 0V, R_L = 2kΩ, V_{CM} = V_{OUT} = V_S/2, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Characteristics					
Input Offset Voltage (V_{OS})	V_S = ±15V		±100	±350	μV
	-40℃ ≤ T_A ≤ +85℃			±450	
Input Offset Voltage Drift ($\Delta V_{OS}/\Delta T$)	V_S = ±15V		1		μV/℃
Input Bias Current (I_B)	V_{CM} = V_{OUT} = V_S/2		±40	±300	nA
	-40℃ ≤ T_A ≤ +85℃			±550	
Input Offset Current (I_{OS})	V_{CM} = V_{OUT} = V_S/2		±25	±165	nA
Input Common Mode Voltage Range (V_{CM})		(-V_S) + 1.8		(+V_S) - 1.8	V
Common Mode Rejection Ratio (CMRR)	V_S = ±5V, (-V_S) + 1.8V ≤ V_{CM} ≤ (+V_S) - 1.8V	114	130		dB
	-40℃ ≤ T_A ≤ +85℃	111			
	V_S = ±18V, (-V_S) + 1.8V ≤ V_{CM} ≤ (+V_S) - 1.8V	125	136		dB
	-40℃ ≤ T_A ≤ +85℃	120			
Open-Loop Voltage Gain (A_{OL})	V_S = ±5V to ±18V, (-V_S) + 0.2V ≤ V_{OUT} ≤ (+V_S) - 0.2V, R_L = 10kΩ	122	150		dB
	-40℃ ≤ T_A ≤ +85℃	119			
	V_S = ±5V to ±18V, (-V_S) + 0.6V ≤ V_{OUT} ≤ (+V_S) - 0.6V, R_L = 2kΩ	123	150		
	-40℃ ≤ T_A ≤ +85℃	120			
Input Impedance					
Differential			32k || 10		Ω || pF
Common Mode			10^9 || 4		Ω || pF
Output Characteristics					
Output Voltage Swing from Rail	V_S = ±5V to ±18V, R_L = 10kΩ		±35	±50	mV
	V_S = ±5V to ±18V, R_L = 2kΩ		±150	±210	
Output Short-Circuit Current (I_{SC})	V_S = ±3.6V to ±18V		±110		mA
Audio Performance					
Total Harmonic Distortion + Noise (THD+N)	G = +1, V_{OUT} = 3V_{RMS}, f = 1kHz		0.00002		%
			-134		dB
Intermodulation Distortion (IMD)	G = +1, V_{OUT} = 3V_{RMS}, SMPTE/DIN, Two-Tone, 4:1 (60Hz and 7kHz)		0.000015		%
			-136		dB
	G = +1, V_{OUT} = 3V_{RMS}, DIM 30, (3kHz square wave and 15kHz sine wave)		0.000032		%
			-130		dB
	G = +1, V_{OUT} = 3V_{RMS}, CCIF Twin-Tone, (19kHz and 20kHz)		0.00013		%
			-118		dB
Frequency Response					
Gain-Bandwidth Product (GBP)	G = +100		45		MHz
	G = +1		16		
Slew Rate (SR)	G = -1		16		V/μs
Full Power Bandwidth (1)	V_{OUT} = 1V_{P-P}		2		MHz
Overload Recovery Time	G = -10		500		ns
Channel Separation (Dual)	f = 1kHz		-140		dB

NOTE: 1. Full-power bandwidth equals to the value of slew rate/(2π × V_P).

ELECTRICAL CHARACTERISTICS (continued)

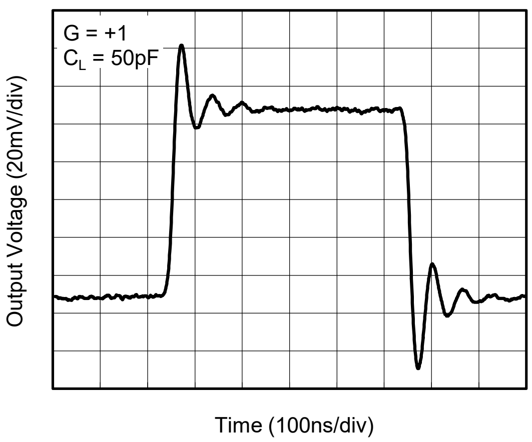
(At T_A = +25℃, V_S = ±5V to ±18V, GND = 0V, R_L = 2kΩ, V_{CM} = V_{OUT} = V_S/2, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Noise Performance					
Input Voltage Noise	f = 20Hz to 20kHz		1.7		μV_{P-P}
Input Voltage Noise Density (e_n)	f = 10Hz		5		nV/$\sqrt{Hz}$
	f = 100Hz		2		
	f = 1kHz		1.6		
Input Current Noise Density (i_n)	f = 1kHz		6		pA/$\sqrt{Hz}$
Power Supply					
Supply Voltage (V_S)		±3.6		±18	V
Specified Voltage (V_S)		±5		±18	V
Quiescent Current/Amplifier (I_Q)	I_{OUT} = 0		4.1	5.5	mA
	-40℃ ≤ T_A ≤ +85℃			5.8	
Shutdown Current (I_{SHDN})	V_S = ±5V to ±18V, I_{OUT} = 0A, EN = GND		100	200	μA
Power Supply Rejection Ratio (PSRR)	V_S = ±3.6V to ±18V		0.1	0.6	μV/V
	-40℃ ≤ T_A ≤ +85℃			1.6	
EN Control					
Input High Voltage (V_{IH})	V_S = ±3.6V to ±18V, GND = 0V	1.8		MIN (5, +V_S)	V
Input Low Voltage (V_{IL})	V_S = ±3.6V to ±18V, GND = 0V			0.4	V
Input Leakage Current (I_{IN})	V_S = ±5V to ±18V, GND = 0V, EN = 0V or 5V		1	1.8	μA
EN Pull-Down Resistor (R_{EN})			4		MΩ

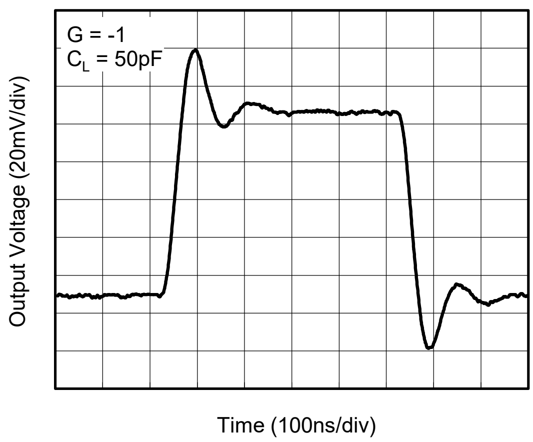
TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, V_S = ±15V, GND = 0V and R_L = 2kΩ, unless otherwise noted.

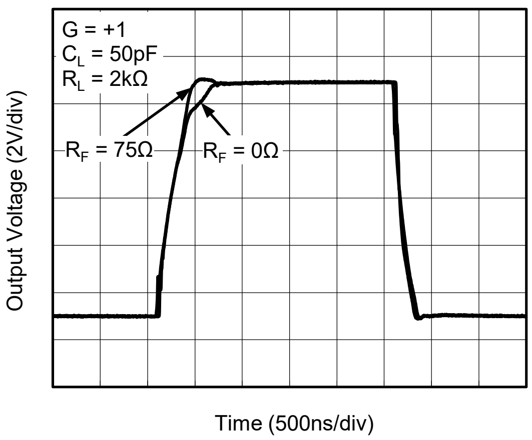
Small-Signal Step Response (100mV)



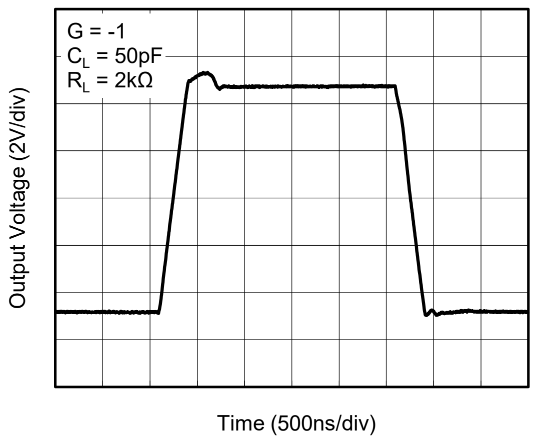
Small-Signal Step Response (100mV)



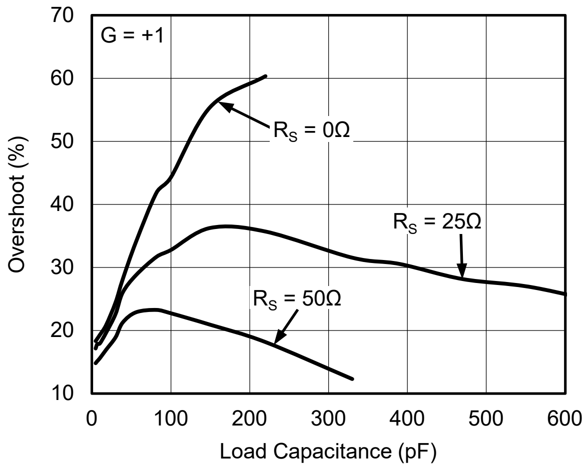
Large-Signal Step Response



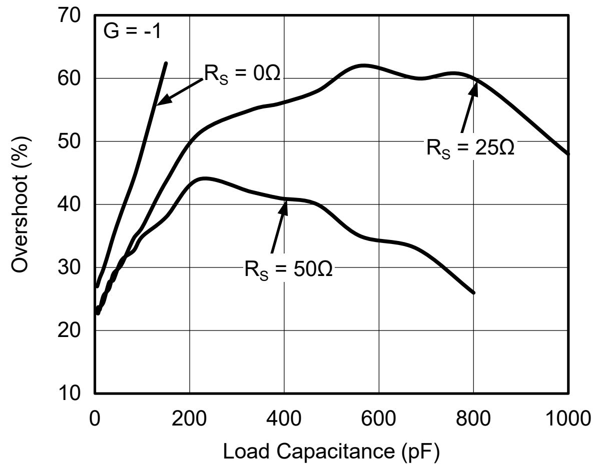
Large-Signal Step Response



Small-Signal Overshoot vs. Capacitive Load (100mV Output Step)



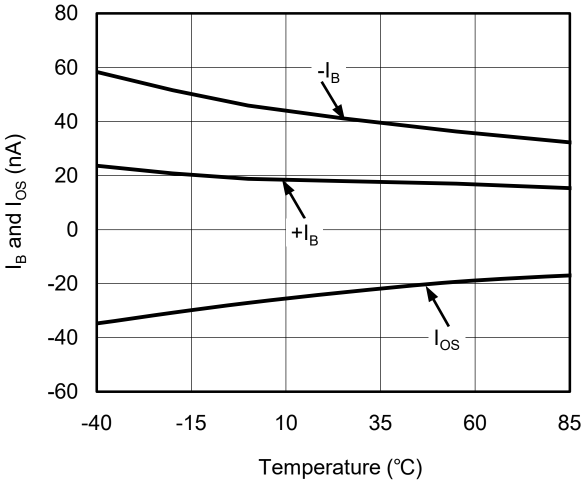
Small-Signal Overshoot vs. Capacitive Load (100mV Output Step)



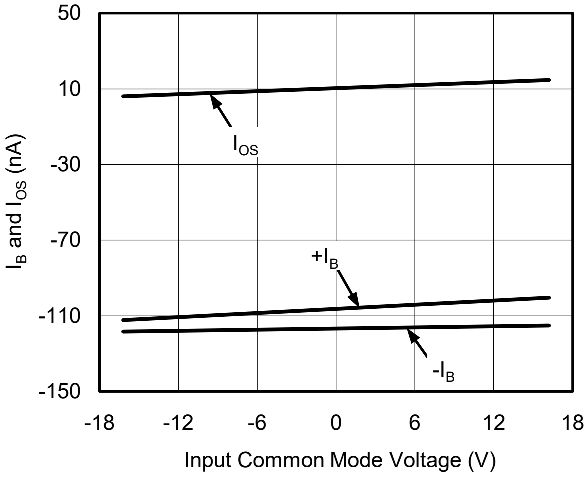
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = ±15V, GND = 0V and R_L = 2kΩ, unless otherwise noted.

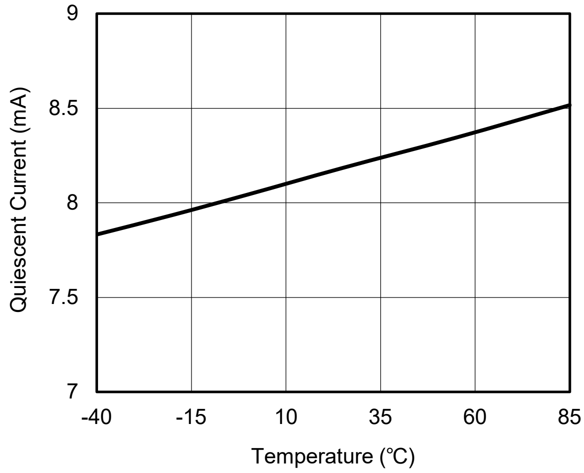
I_B and I_{OS} vs. Temperature



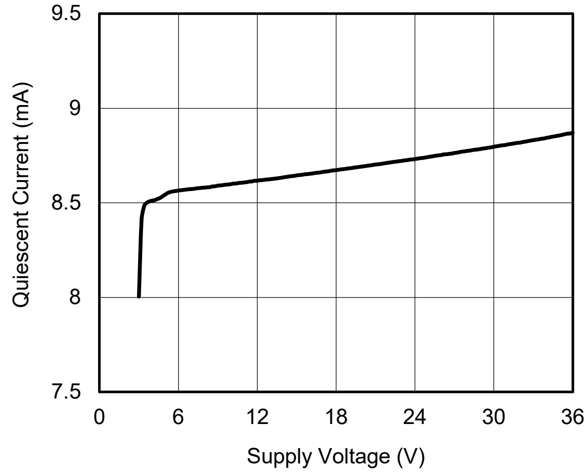
I_B and I_{OS} vs. Input Common Mode Voltage



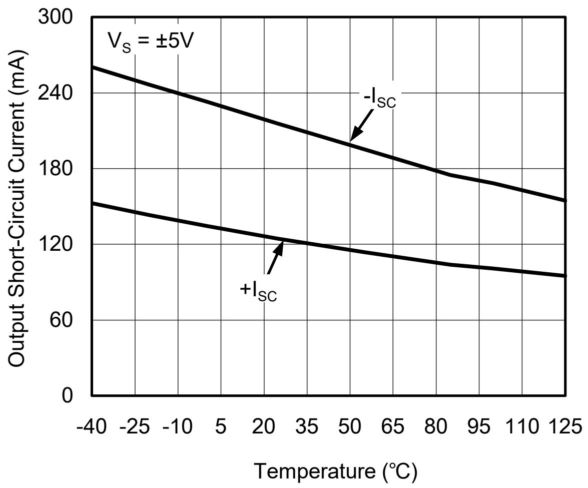
Quiescent Current vs. Temperature



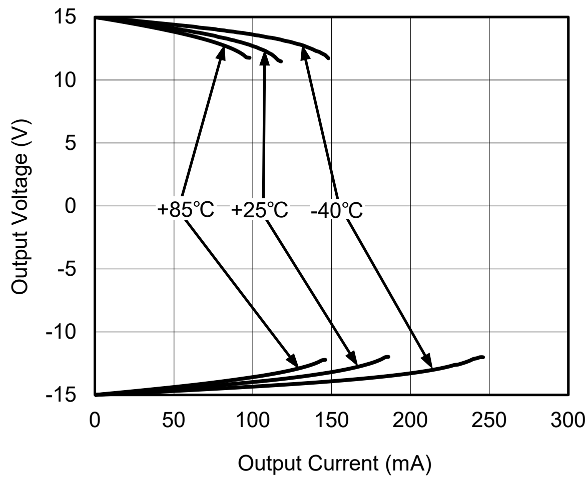
Quiescent Current vs. Supply Voltage



Output Short-Circuit Current vs. Temperature



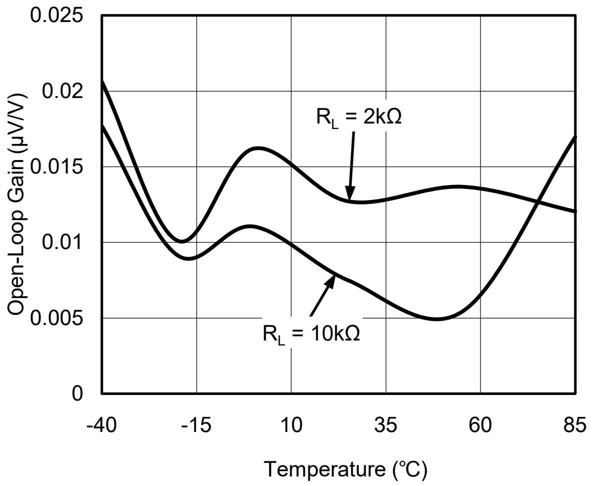
Output Voltage vs. Output Current



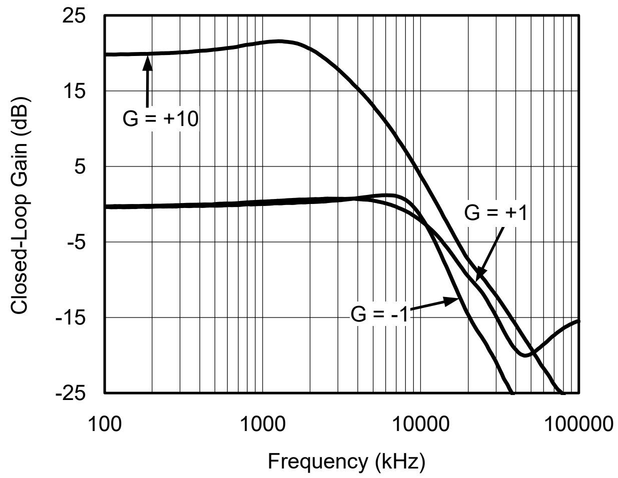
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = ±15V, GND = 0V and R_L = 2kΩ, unless otherwise noted.

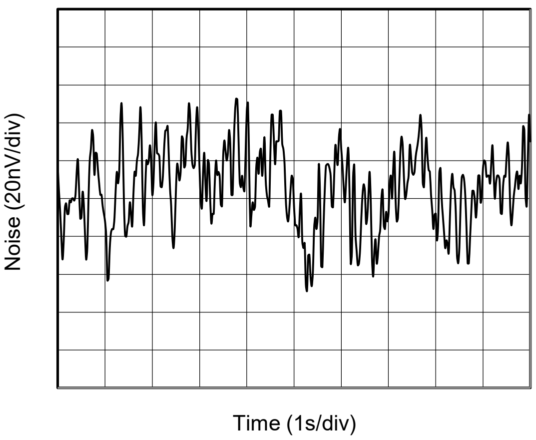
Open-Loop Gain vs. Temperature



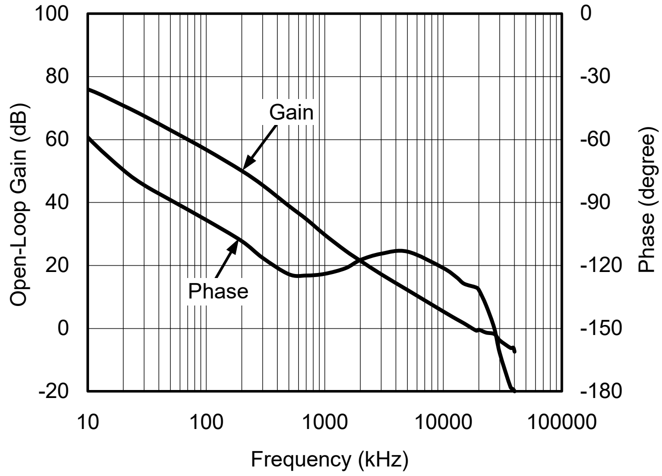
Closed-Loop Gain vs. Frequency



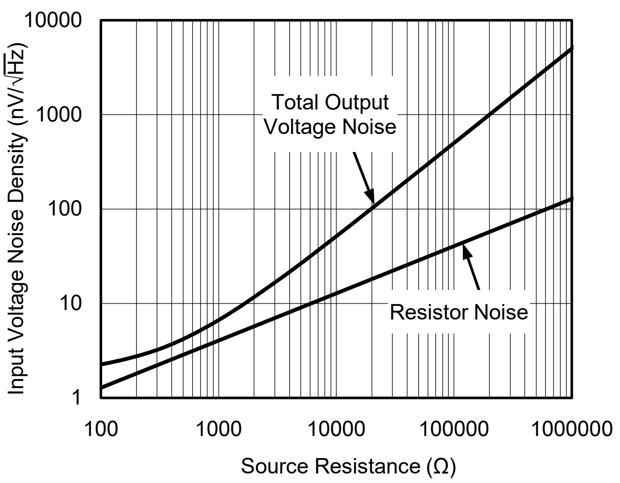
0.1Hz to 10Hz Noise



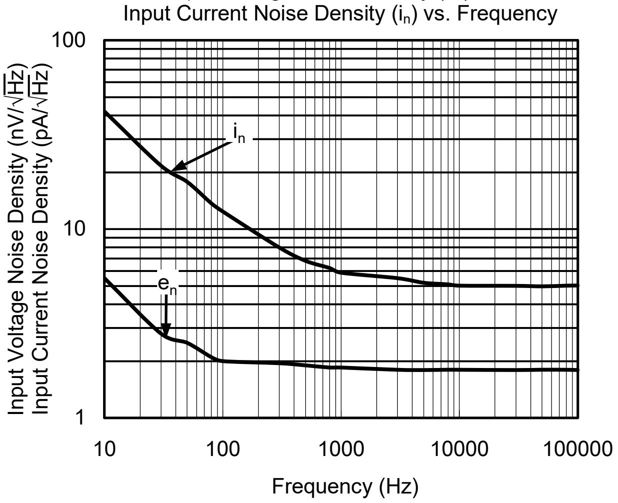
Open-Loop Gain and Phase vs. Frequency



Input Voltage Noise Density vs. Source Resistance

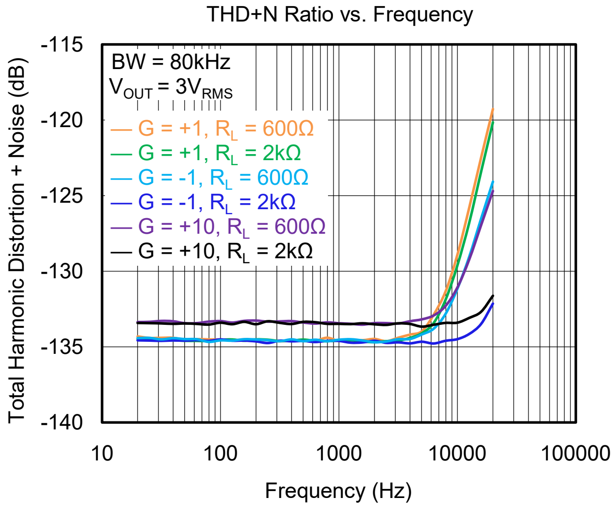


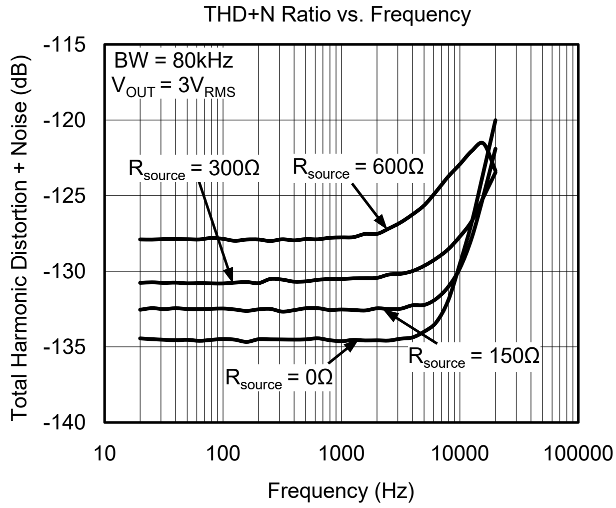
Input Voltage Noise Density (e_n) and
Input Current Noise Density (i_n) vs. Frequency

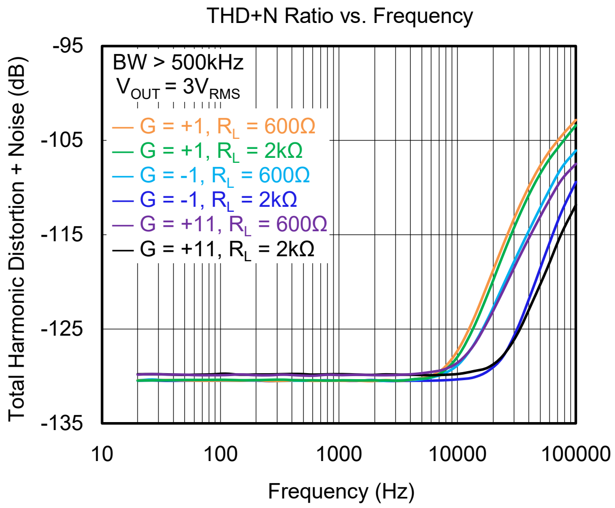


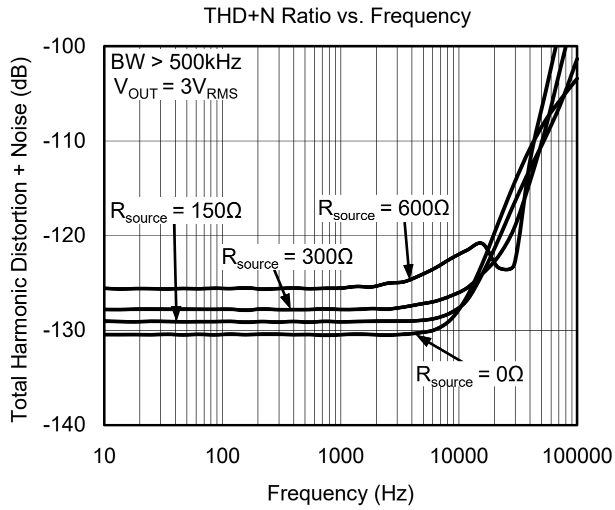
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

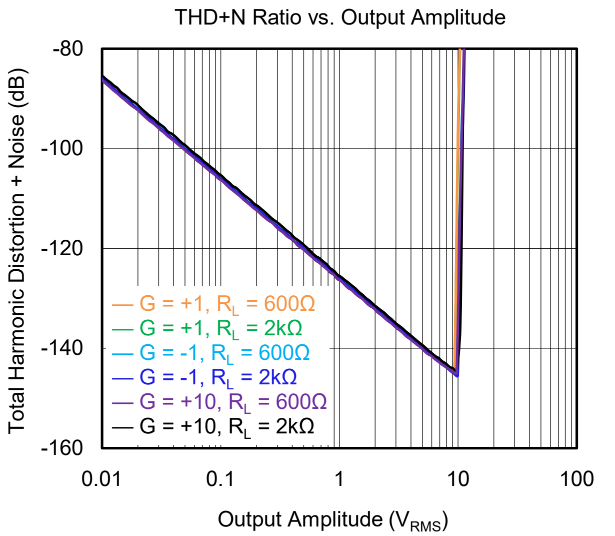
At T_A = +25℃, V_S = ±15V, GND = 0V and R_L = 2kΩ, unless otherwise noted.

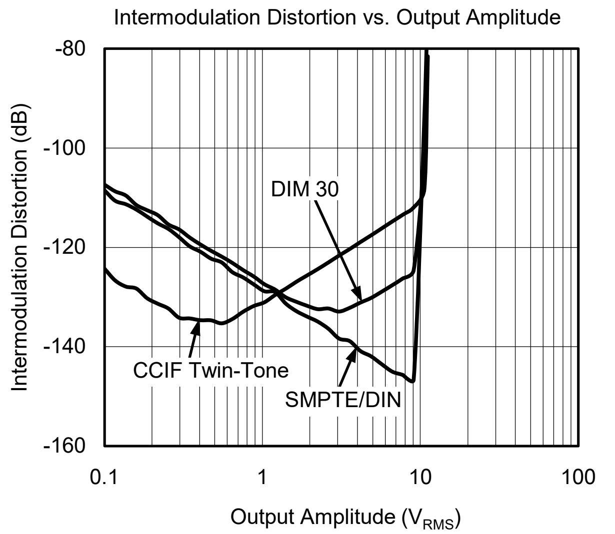






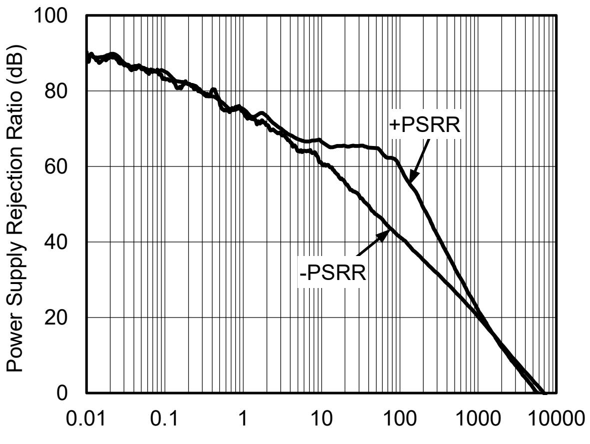


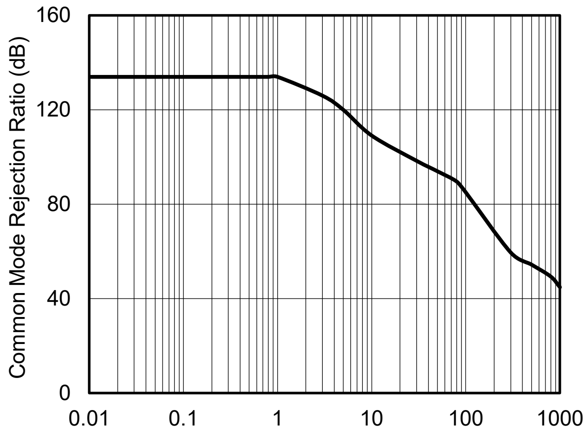


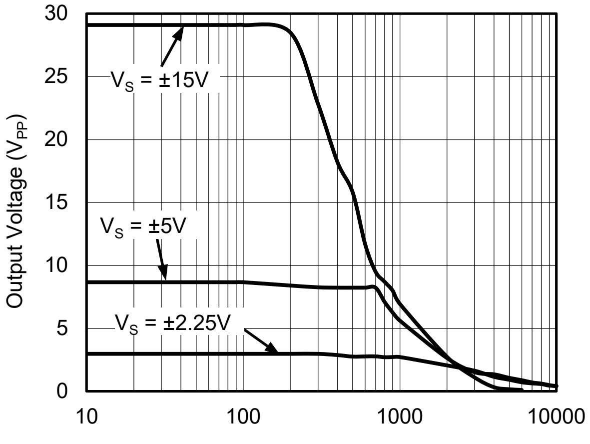


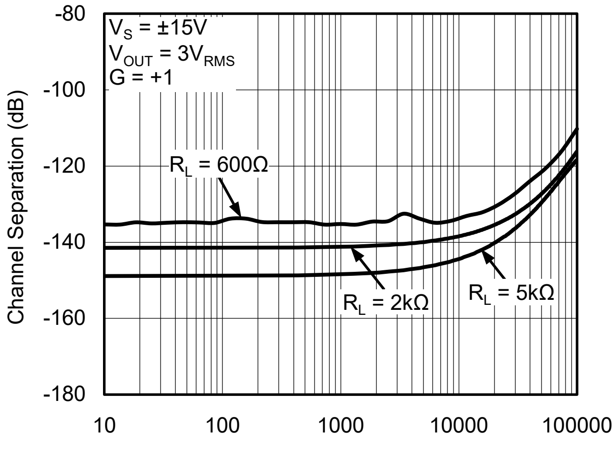
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = ±15V, GND = 0V and R_L = 2kΩ, unless otherwise noted.









APPLICATION INFORMATION

The benefit of SGM8261-5 is that it can maintain stability at unity-gain and the noise of it is extreme low; and there is no output phase reversal for this driver. For noisy power supplies, a decoupling capacitor is necessary for operation. It is recommended that a 0.1μF capacitor can be taken into account.

For normal operation, the single power supply range is from 3.6V to 36V while dual power supply range is from ±3.6V to ±18V. However, in some special cases, the absolute values of positive and negative power supplies are not equal to dual power supply operations, and SGM8261-5 can work well in this case. For instance, the positive value of power supply is 25V while the negative one is -5V. For normal operation, the users should always make sure that the common mode voltage at the input of the driver is within the typical range. Also, the typical temperature range to ensure that the driver can work in normal is from -40℃ to +85℃.

Input Protection

The back-to-back diode is used to protect the input from large differential input voltage. However, there is no consequence for it in wide range of the applications. Also, for the application of G = +1, the diode can forward bias the input signal with fast ramp as the operational amplifier cannot respond quickly for it. The input current should be limited within the range of 10mA for the forward bias of the internal back-to-back diode, and the user can use R_F and R_I externally to limit the input current. Unfortunately, the external resistors can degrade the low noise performance of SGM8261-5, and the following figure illustrates the application with the resistors of R_F and R_I.

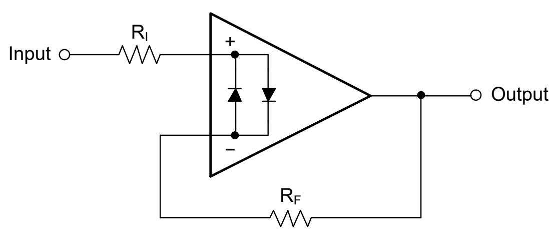


Figure 1. Input Current Limit

Noise Performance

The equation of the circuit noise for the application of unity-gain for varying source impedance is shown in Equation 1. However, there is no addition noise condition for R_F in the application of Figure 2.

For the application in Figure 2, the gain-bandwidth product is 16MHz in the unity-gain condition. For the noise contribution of the operational amplifier, there are components of current and voltage noise. The V_{OS} is modeled as the time-varying voltage component of the noise contribution. The I_B is modeled as the time-varying current component of the noise contribution, and this I_B is multiplied with the source impedance R_S to obtain a voltage component. Therefore, the value of R_S depends on the level of circuit noise (Figure 2). If the value of R_S is low, the voltage noise e_n^2 will dominate to the contribution of the noise. Because of the benefit of the noise performance, SGM8261-5 will be a good choice for the application where the source impedance R_S is below 1kΩ.

The calculation of the circuit noise for Figure 2 is shown as below:

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

where:
e_n is the voltage noise.
i_n is the current noise.
R_S is the source impedance.
k is the Boltzmann's constant, which is 1.38×10^{-23}J/K.
T is the temperature in Kelvin (K).

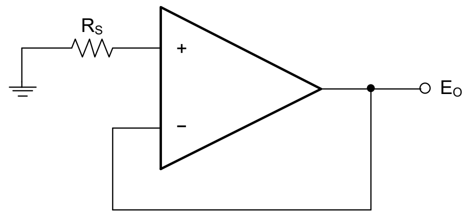


Figure 2. Unity-Gain Buffer Configuration

APPLICATION INFORMATION (continued)

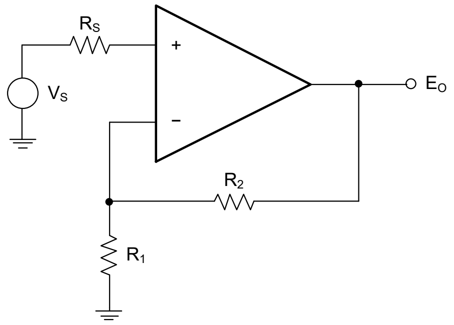
Calculations of Basic Noise Condition

For the application of low noise condition, there are several noise sources should be taken into account, which are the noise generated from the signal source, feedback resistor and the operational amplifier itself. To convert them to the format of noise and calculate the total generated noise from the circuit, these components should be summed using root-square.

The thermal noise of the circuit is produced by the resistances of the circuit. To reduce the total noise contribution of the circuit, it is recommended that selecting small value of resistors and using SGM8261-5 will be a good choice.

The topology of non-inverting and inverting amplifiers with gain is shown in Figure 3. In these configurations, the noise is contributed by the feedback resistor R_2.

The voltage noise components can be created by the current noise reacts with the feedback resistor. To minimize these sources of noise, the selection of the feedback resistor R_2 is significant. The following equations illustrate the details of the noise configuration.



Noise at the output:

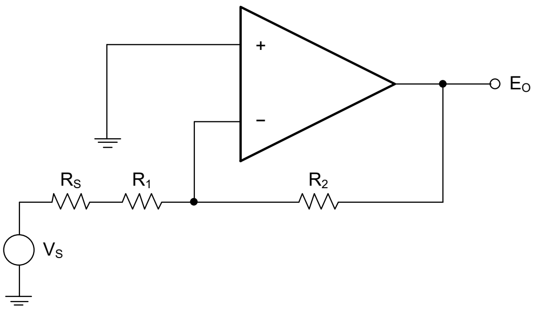
$$E_O^2 = \left[1+\frac{R_2}{R_1}\right]^2 e_n^2 + e_1^2 + e_2^2 + (i_nR_2)^2 + e_S^2 + (i_nR_S)^2\left[1+\frac{R_2}{R_1}\right]^2$$

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 Non-Inverting Gain Configuration



Noise at the output:

$$E_O^2 = \left[1+\frac{R_2}{R_1+R_S}\right]^2 e_n^2 + e_1^2 + e_2^2 + (i_nR_2)^2 + e_S^2$$

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

Noise in Inverting Gain Configuration

NOTE: At 1kHz, the noise densities of voltage and current are equal to $1.6nV/\sqrt{Hz}$ and $6pA/\sqrt{Hz}$ respectively.

Figure 3. Noise Calculation in Gain Configurations

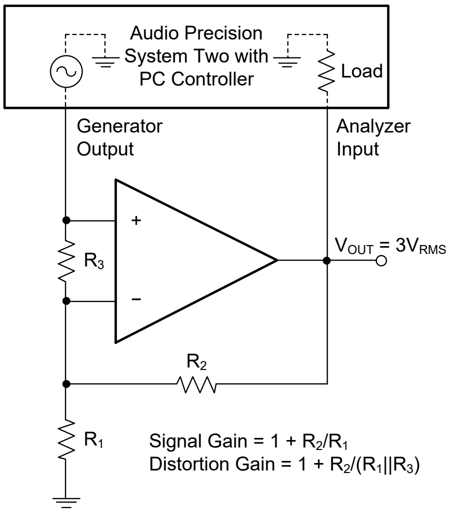
APPLICATION INFORMATION (continued)

Total Harmonic Distortion Measurements

The distortion characteristics of SGM8261-5 is excellent, and the value of THD + N is lower than 0.00015% (G = +1, V_{OUT} = $3V_{RMS}$, BW = 80kHz) over the range of 20Hz to 20kHz with a 2kΩ load.

However, the distortion of SGM8261-5 is below the limit of measurement for most of the distortion analyzers. The test circuit in Figure 4 is a good method to measure the distortion accurately by boosting the distortion within the measurement limit.

The distortion of SGM8261-5 can be seen as the internal error of it. For the circuit in Figure 4, the distortion is multiplied by 101 times (40dB). It is equivalent to the noise gain as the resistor R_3 change the noise gain of the non-inverting amplifier while the signal gain remains unchanged so that the measurement resolution is multiplied by 101 times. The condition of load resistor and input signal source is the same as the case without the contribution of R_3. Also, the value of R_3 should be kept small to reduce the error of distortion measurement.



Signal Gain	Distortion Gain	R_1	R_2	R_3
+1	101	∞	1kΩ	10Ω
-1	101	4.99kΩ	4.99kΩ	49.9Ω
+10	110	549Ω	4.99kΩ	49.9Ω

Figure 4. Distortion Test Circuit

This technology can boost the distortion so that it is within the capability of the measurement equipment. The noise analyzer and audio precision system two distortion are taken into account to be used to measure the distortion for the value of datasheet, and these types of equipment can simplify the repetitive measurement. However, this distortion can also be measured with the measurement instrument manually.

Capacitive Loads

Different gain, load and condition of operation can improve the dynamic characteristics of SGM8261-5. When the closed-loop gain is equal to 1V/V with high capacitive load, the output will be oscillated which means that there is a gain peaking. To improve this issue, it is recommended that isolating the output of the driver and the capacitive load is a good choice. A 50Ω resistor should be taken into account in series with the output.

Power Dissipation

A 2kΩ resistive load can be driven with ±18V dual power supplies. The value of power dissipation is proportional to the voltage of power supply. Also, the heat dissipation is improved by the construction of copper leadframe, which is much better than the conventional materials. A good PCB layout can also improve the temperature of junction, which means that the wide trace can dissipate the heat of the driver. Moreover, soldering the driver is better than using a socket for the effect of heat dissipation.

Electrical Overstress

The electrical overstress is one of the problems that the users care about. Usually, the issue of the electrical overstress is appeared at the input of the amplifier, but this may involve the voltage level of supply and output pins as well. For the electrical overstress of them, it is determined by the breakdown voltage of the semiconductor and the external circuit which is connected to the specific pin. Moreover, the Electrostatic discharge (ESD) diode is used to prevent the operational amplifier from ESD or high voltage.

APPLICATION CIRCUIT

The following figure illustrates the operation of SGM8261-5 in professional audio headphones. The schematic of left stereo channel is shown in Figure 5, which is equivalent to that of the right stereo channel. An I/V converter and differential multiple feedback (MFB) low-pass filter is used for the quality of the audio signal.

Operating Voltage

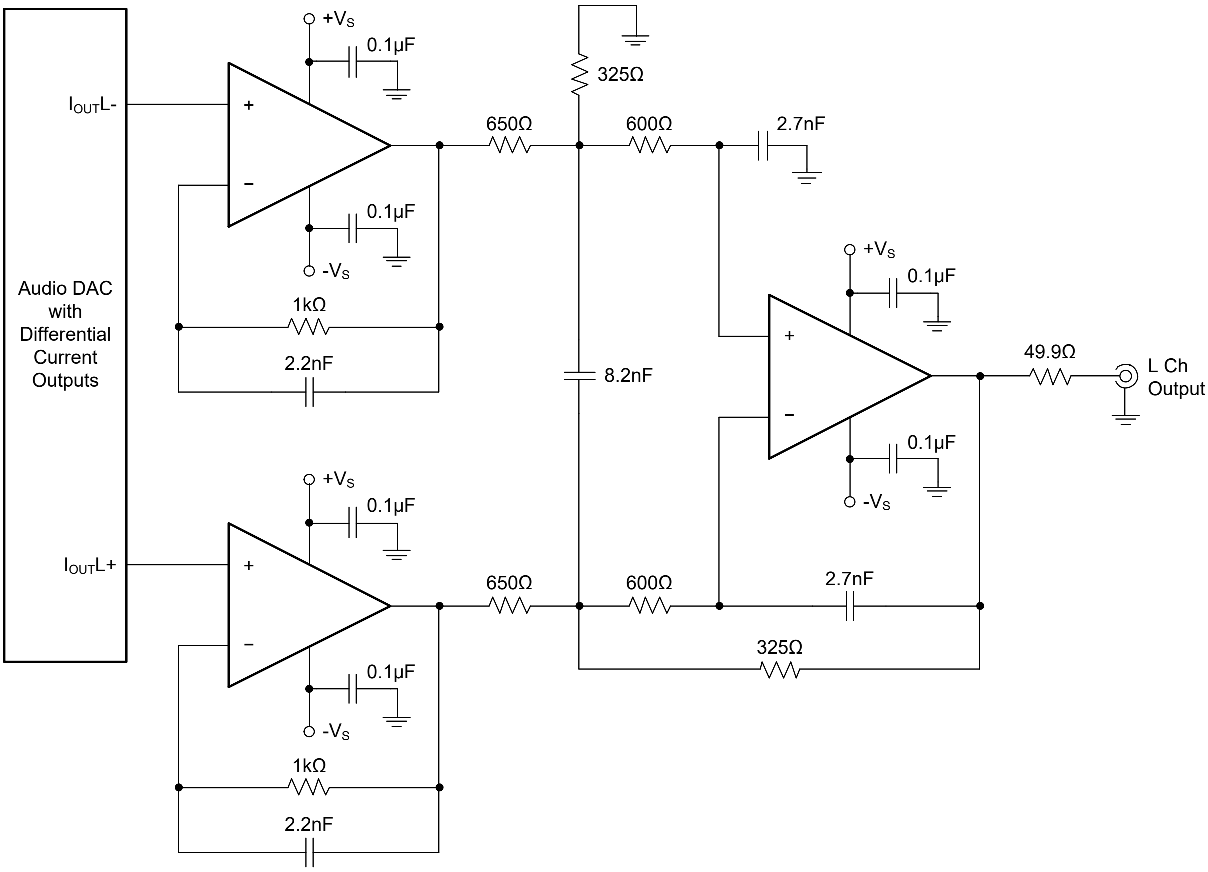


Figure 5. Audio DAC Post Filter (I/V Converter and MFB Differential Low-Pass Filter)

REVISION HISTORY

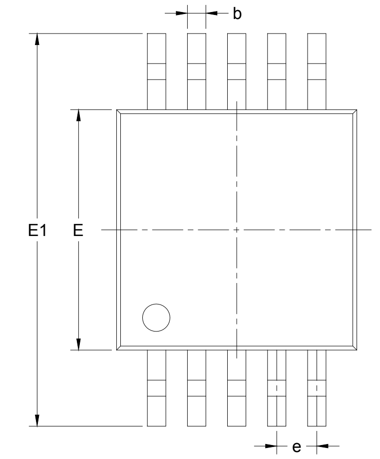
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

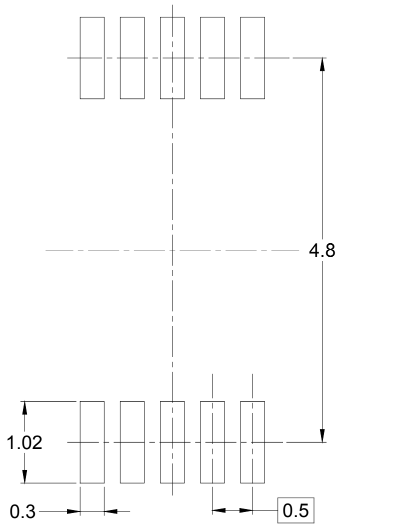
MAY 2017 – REV.A to REV.A.1	Page
Changed General Description section	1

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

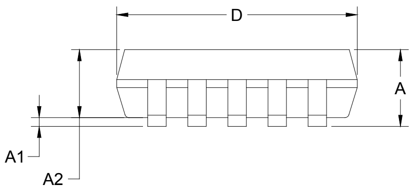
PACKAGE OUTLINE DIMENSIONS

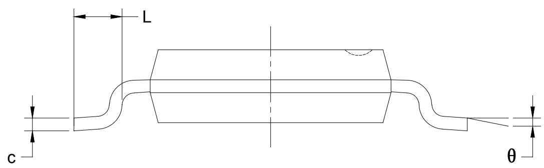
MSOP-10





RECOMMENDED LAND PATTERN (Unit: mm)

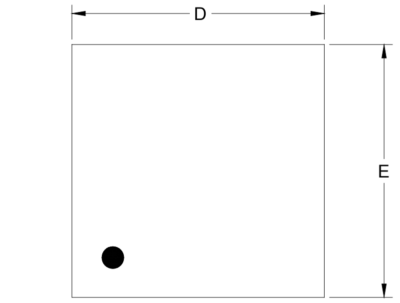




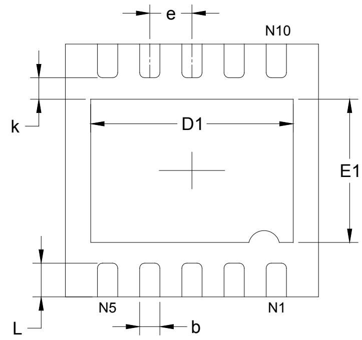
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.180	0.280	0.007	0.011
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.500 BSC		0.020 BSC	
L	0.400	0.800	0.016	0.031
θ	0°	6°	0°	6°

PACKAGE OUTLINE DIMENSIONS

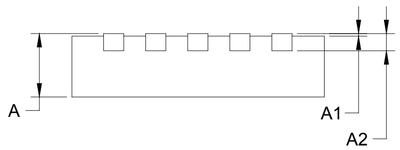
TDFN-3×3-10L



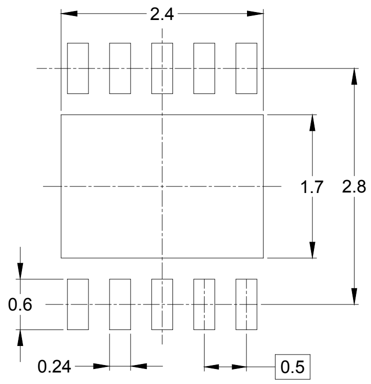
TOP VIEW



BOTTOM VIEW



SIDE VIEW

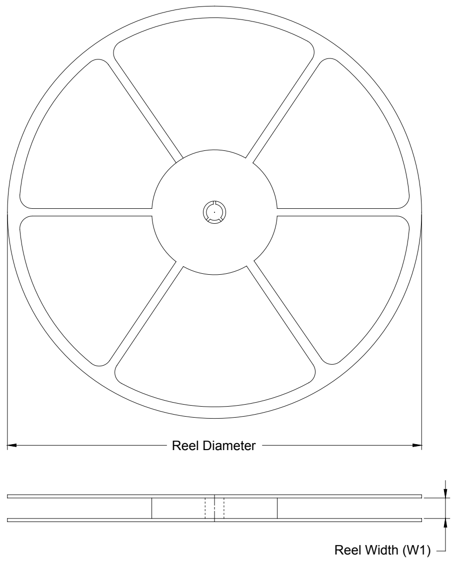


RECOMMENDED LAND PATTERN (Unit: mm)

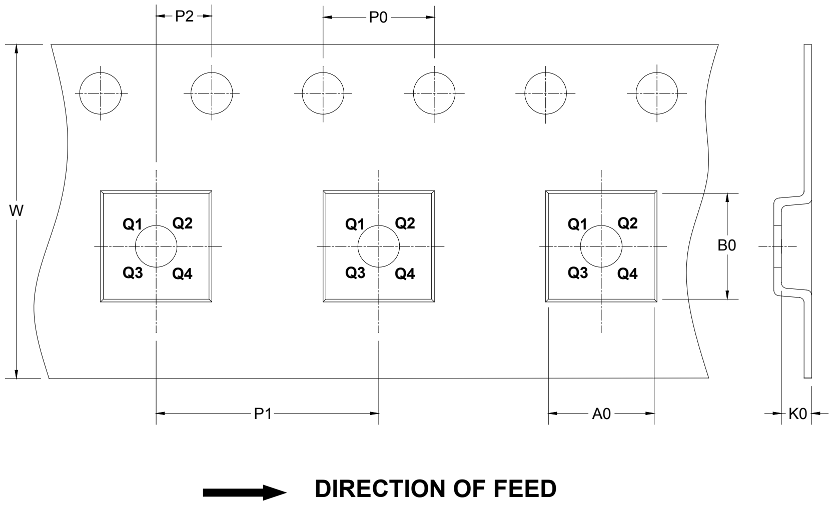
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	2.900	3.100	0.114	0.122
D1	2.300	2.600	0.091	0.103
E	2.900	3.100	0.114	0.122
E1	1.500	1.800	0.059	0.071
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.500 TYP		0.020 TYP	
L	0.300	0.500	0.012	0.020

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



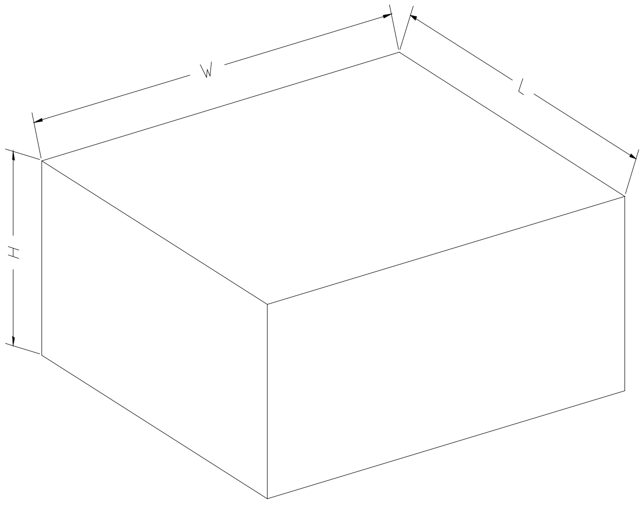
NOTE: The picture is only for reference. Please make the object as the standard.

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
MSOP-10	13″	12.4	5.20	3.30	1.20	4.0	8.0	2.0	12.0	Q1
TDFN-3×3-10L	13″	12.4	3.35	3.35	1.13	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
13″	386	280	370	5

DD0002