General Description

The SAH2622 is a dual, low noise, high speed operational amplifier with voltage feedback function. The output swing is rail-to-rail with heavy loads. This maximizes the dynamic range and offers high linearity.
The SAH2622 features 3.5nV/Hz low voltage noise at 100kHz with ultra-low distortion. It also has 22MHz wide bandwidth at -3dB and 33V/µs high slew rate.
The device is unity-gain stable and has high output drive capability.The SAH2622 is available in Green SOP-8 packages. It operates over an ambient temperature range of -40°C to +85°C.

Features

- Superior Sound Quality
- Low Offset Voltage: ±500µV (MAX)
- Ultra Low Noise: 3.5nV/ Hz at 1kHz
- Ultra Low Distortion: 0.00005% at 1kHz
- High Slew Rate: 33 V/µs
- Gain-Bandwidth Product: 22MHz (G = +1)
- High Open-Loop Gain: 110dB
- Unity-Gain Stable
- Low Quiescent Current: 4mA/Amplifier
- Rail-to-Rail Output
- Support Single or Dual Power Supplies: 4.5V to 36V or ±2.25V to ±18V
- Operating temperature: -40°C to +85°C
- Available in Green SOP-8 Package

Package Marking and Ordering Information

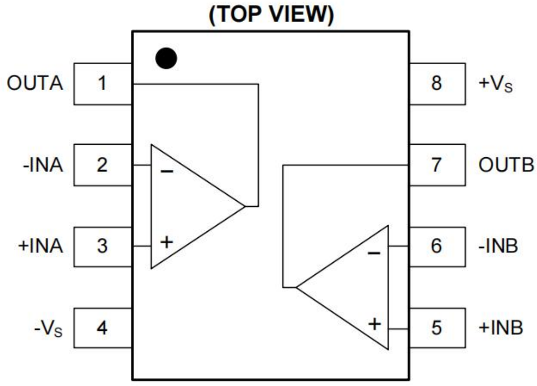
Part Number	Marking	Package	Units/Tube	Units/Reel
SAH2622	SAH2622	SOP8		4000

Applications

- Audio Processing
- General-Purpose AC Equipment
- Twisted-Pair Wiring Drivers

Pin Configurations

(TOP VIEW)



SOP-8

Electrical Characteristics

(At T_A = +25℃ , V_S = 4.5V to 36V or V_S = ±2.25V to ±18V, G = +1, R_{LOAD} = 32Ω, V_{CM} = V_{OUT} = V_S/2, unless otherwise noted.) (1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
DC Performance					
Input Offset Voltage (V_{OS})			±100	±500	μV
	-40℃ to +85℃			±610	
Input Offset Voltage Match			±100	±700	μV
Input Offset Voltage Drift ($\Delta V_{OS}/\Delta T$)			0.5		μV/℃
Input Bias Current (I_B)	V_{CM} = V_S/2		±40	±300	nA
	-40℃ to +85℃			±370	
Input Offset Current (I_{OS})	V_{CM} = V_S/2		±10	±120	nA
Open-Loop Voltage Gain (A_{OL})	V_{OUT} = ±1V, V_S = ±2.5V or 5V	109	115		dB
	V_{OUT} = ±2V, V_S = ±5V or 10V	106	115		
	V_{OUT} = ±3V, V_S = ±18V or 36V	95	110		
Input Characteristics					
Differential Input Impedance	V_S = ±2.25V or 4.5V		38 ‖ 20		kΩ ‖ pF
	V_S = ±18V or 36V		45 ‖ 15		
Common Mode Input Impedance	V_S = ±2.25V or 4.5V		4 ‖ 6		GΩ ‖ pF
	V_S = ±18V or 36V		20 ‖ 5		
Input Common Mode Voltage Range (V_{CM})		(-V_S) + 2		(+V_S) - 2	V
Common Mode Rejection Ratio (C_{MRR})	ΔV_{CM} = ±0.5V, V_S = ±2.5V or 5V	107	130		dB
	ΔV_{CM} = ±1V, V_S = ±18V or 36V	109	125		
Output Characteristics					
Output Voltage Swing from Rail (V_{OH})	R_{LOAD} = 32Ω, V_S = ±2.5V to ±5V or V_S = 5V to 10V		0.72	1.1	V
Output Voltage Swing from Rail (V_{OL})			0.51	0.64	V
Output Voltage Swing from Rail (V_{OH})	R_{LOAD} = 100Ω		1.1	1.6	V
Output Voltage Swing from Rail (V_{OL})			0.8	1	V
Peak AC Output Current (2)	S_{FDR} ≤ -65dBc, f = 100kHz, V_{OUT} = 0.4VP-P, R_{LOAD} = 1Ω, V_S= ±2.25V or 4.5V		200		mA
	S_{FDR} ≤ -55dBc, f = 100kHz, V_{OUT} = 20VP-P, R_{LOAD} = 32Ω, V_S= ±12V or 24V		310		
Dynamic Performance					
-3dB Gain-Bandwidth Product	V_{OUT} = 0.1V_{P-P}		22		MHz

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
0.1dB Flatness	V_{OUT} = 0.1V_{P-P}		1.6		MHz
Large-Signal Bandwidth	V_{OUT} = 0.5V_{P-P}, V_S = ±2.25V or 4.5V		23		MHz
	V_{OUT} = 2V_{P-P}, V_S = ±18V or 36V		12		
Slew Rate (S_R)	V_{OUT} = 0.5V_{P-P}, V_S = ±2.25V or 4.5V		27		V/µs
	V_{OUT} = 1V_{P-P}, V_S = ±2.5V or 5V		33		
	V_{OUT} = 4V_{P-P}, V_S = ±5V or 10V		49		
	V_{OUT} = 4V_{P-P}, V_S = ±12V or 24V		34		
Noise/Distortion Performance					
Distortion (Worst Harmonic)	fC = 100kHz, V_{OUT} = 1V_{P-P}, G = +2, V_S = ±2.25V or 4.5V		-95		dBc
	fC = 100kHz, V_{OUT} = 2V_{P-P}, G = +2, V_S = ±2.5V or 5V		-93		
	fC = 100kHz, V_{OUT} = 6V_{P-P}, G = +2, V_S = ±5V or 10V		-88		
	fC = 100kHz, V_{OUT} = 20V_{P-P}, G = +5, V_S = ±12V or 24V		-52		
Input Voltage Noise Density (en)	f = 100kHz		3.5		nV/$\sqrt{Hz}$
Input Current Noise Density (in)	f = 100kHz		4		pA/$\sqrt{Hz}$

Electrical Characteristics

(At T_A = +25℃ , V_S = 4.5V to 36V or V_S = ±2.25V to ±18V, G = +1, R_{LOAD} = 32Ω, V_{CM} = V_{OUT} = V_S/2, unless otherwise noted.) (1)

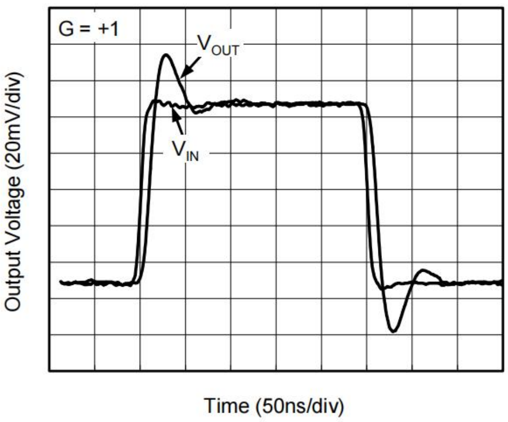
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Power Supply					
Operating Voltage Range (Dual Supply)		±2.25		±18	V
Supply Current/Amplifier (I_Q)			9	11.5	mA
Power Supply Rejection Ratio (PSRR)	ΔV_S = ±0.5V	100	115		dB
Audio Performance					
Total Harmonic Distortion + Noise (THD+N)	f=1kHz, V_{OUT} = 0.5V_{P-P}, V_S = ±2.25V or 4.5V, BW= 80kHz		0.0006		%
			-104		dB
	f =1kHz, V_{OUT} = 1V_{P-P}, V_S = ±2.5V or 5V, BW= 80kHz		0.0003		%
			-110		dB
	f =1kHz, V_{OUT} = 6V_{P-P}, V_S = ±5V or 10V, BW= 80kHz		0.00005		%
			-126		dB
	f = 1kHz, V_{OUT} = 3V_{RMS}, V_S = ±12V or 24V, BW= 80kHz		0.00005		%
			-126		dB

NOTES:
1. Unity-gain can promote characterization. It is recommended to use a gain of 2 or greater to improve stability.
2. Peak AC output current is only for normal AC operation, and continuous DC operation is invalid.

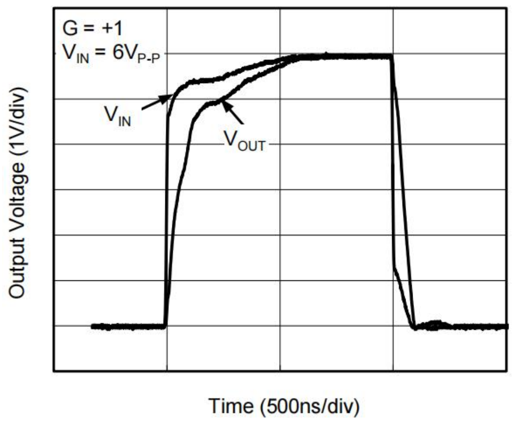
Typical Characteristics

At T_A = +25℃ , V_S = ±5V, R_{LOAD} = 32Ω, unless otherwise noted.

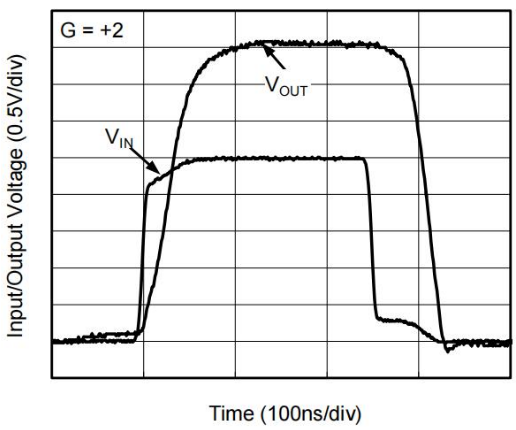
Small-Signal Step Response



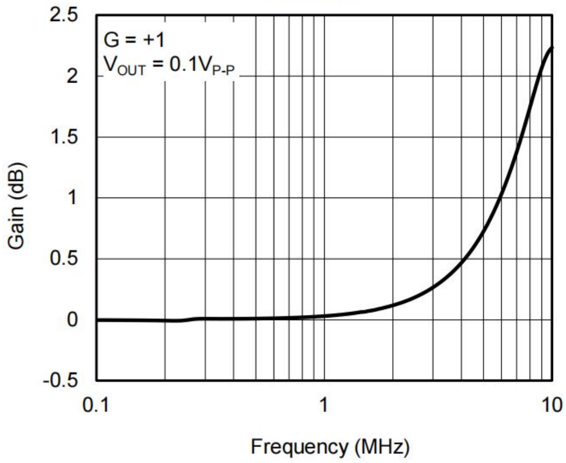
Large-Signal Step Response



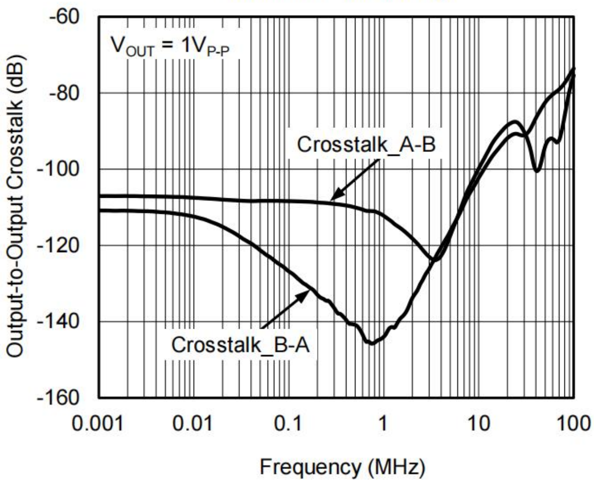
Output Overdrive Recovery



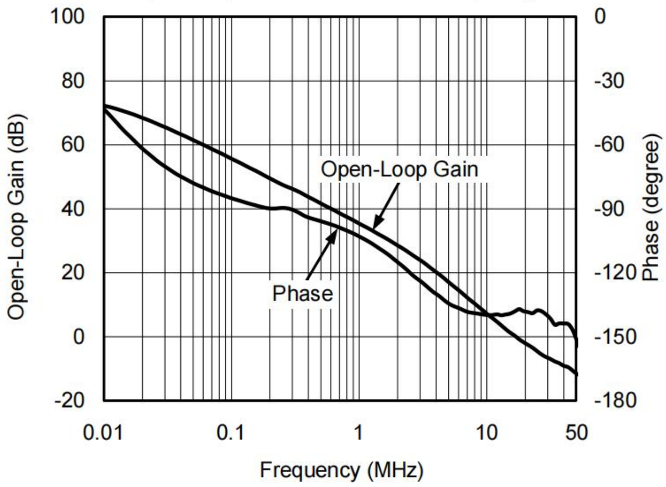
0.1dB Flatness



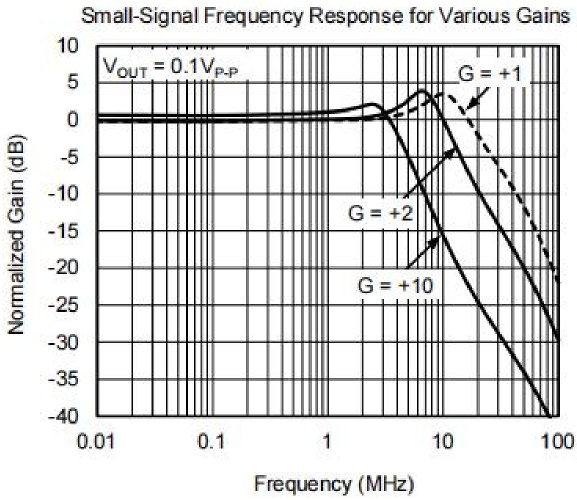
Crosstalk vs. Frequency

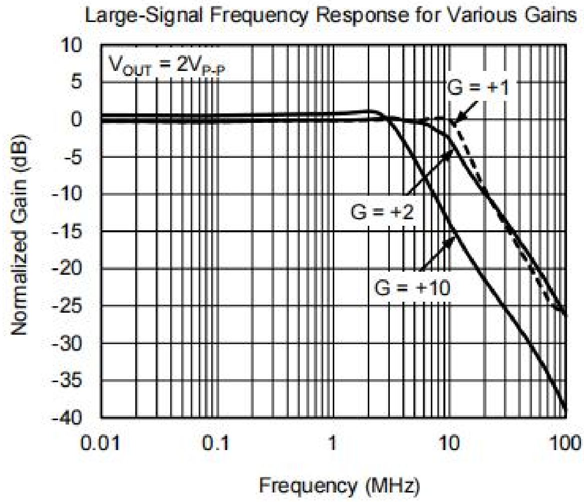


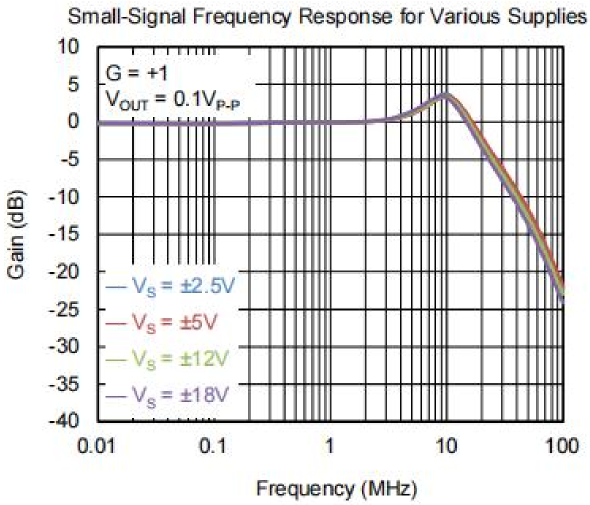
Open-Loop Gain and Phase vs. Frequency

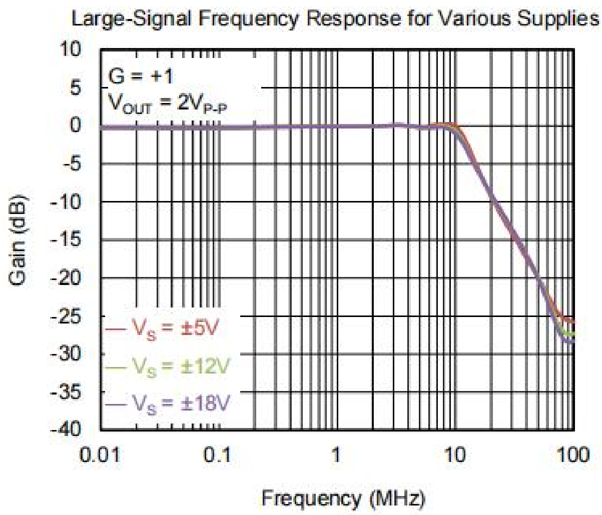


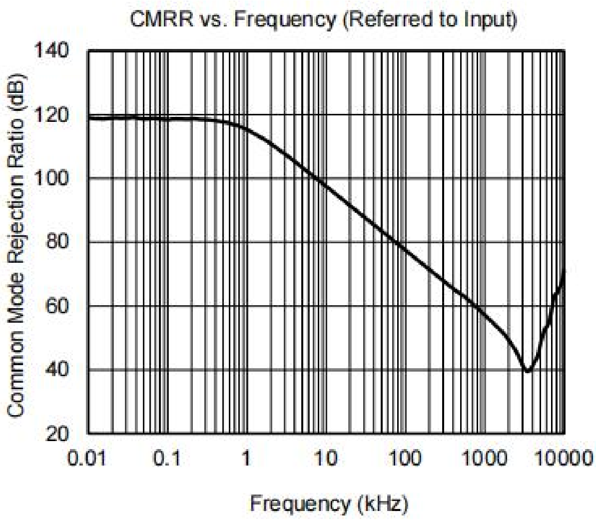
Typical Characteristics(continued)

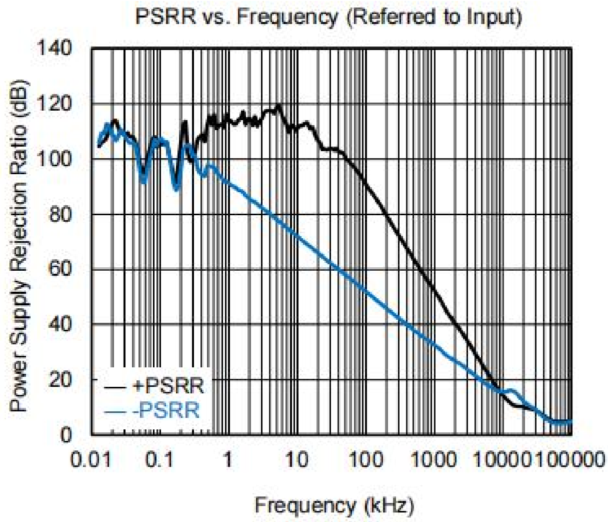




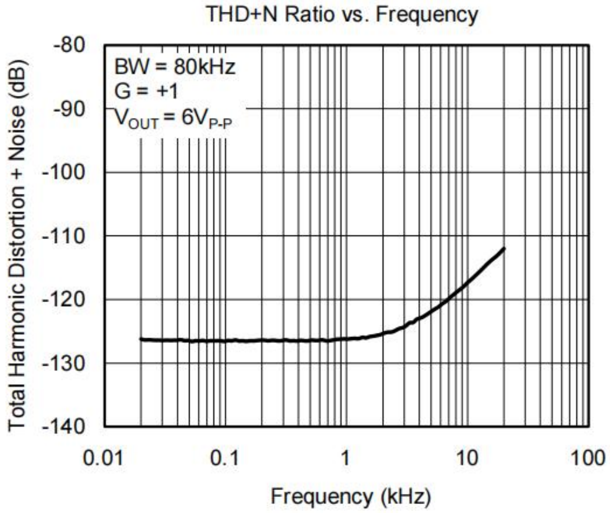


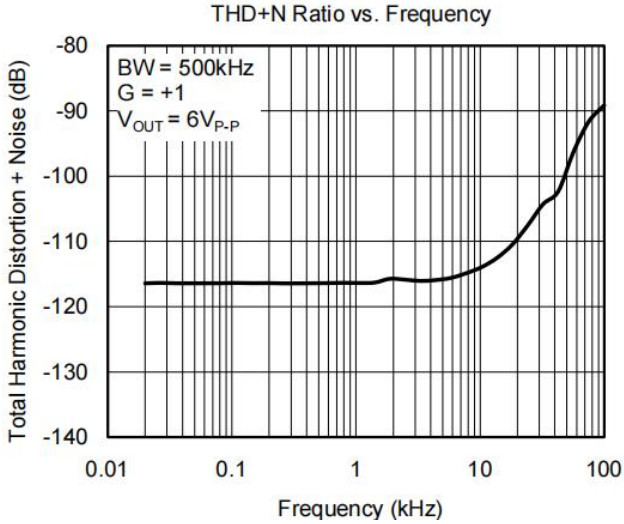


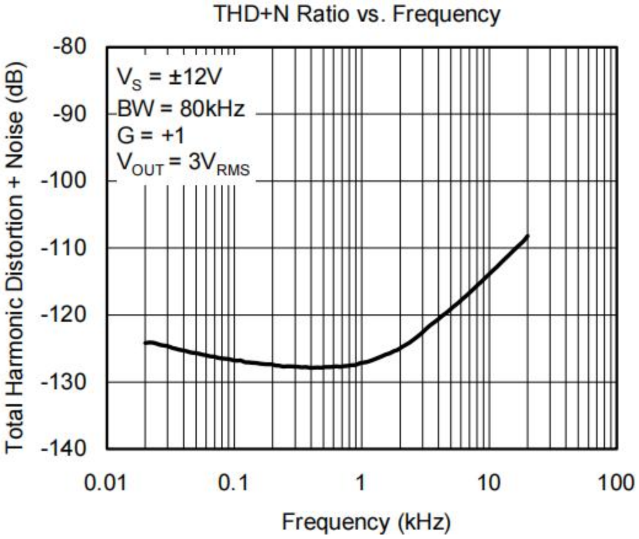


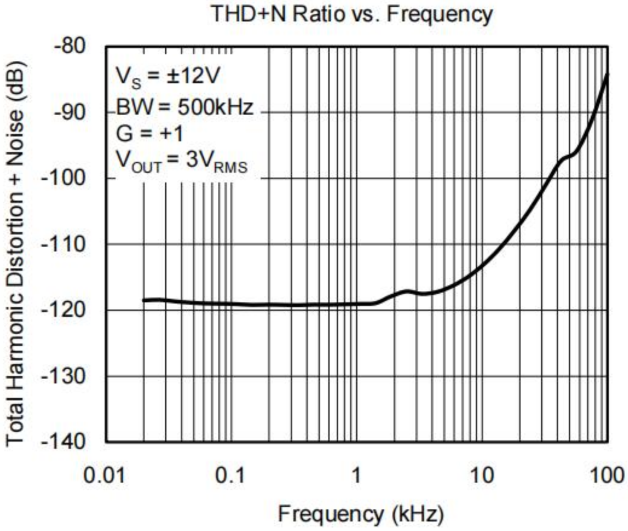


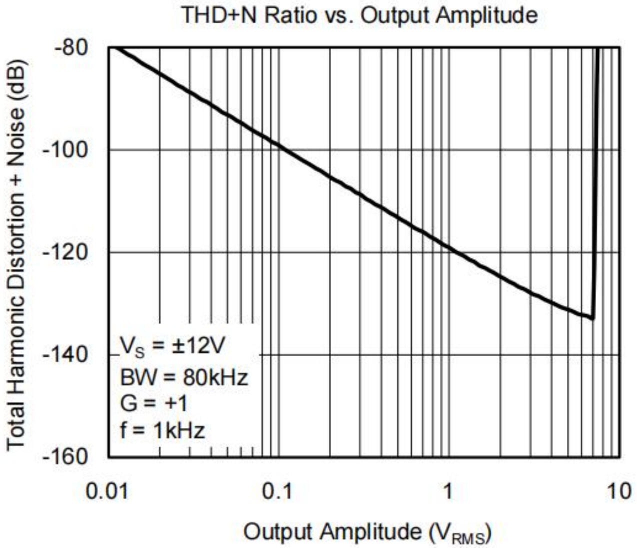
Typical Characteristics(continued)











Application information

The SAH2622 is a dual, low noise, high speed operational amplifier with voltage feedback function. The output swing is rail-to-rail with heavy loads. The SAH2622 is optimized for high voltage operation from ±2.25V to ±18V dual supplies.

Power Supply and Decoupling

The supported voltage of the power supply for SAH2622 is from ±2.25V to ±18V. Also, the customer should ensure that the source of the power supply is low noise and well-regulated. The power supply should be decoupled suitably. The power supply ripple and power dissipation can be decreased dramatically by using low ESR capacitor. The multilayer ceramic capacitors (MLCCs) are good choices for decoupling. A 0.1µF MLCC capacitor should be placed as close as possible (0.125 inches) to the power supply pin of the SAH2622. For decoupling the low-frequency signals, 10µF to 22µF tantalum capacitors should be taken into account so that it can convey the current for large and fast signal changes.

Layout

A good PCB layout is important for the performance of SAH2622 in high speed applications in order to prevent the parasitic effects from the board. The PCB should have a low impedance loop (or ground) to the power supply. Removing the GND planes for all of the layers of the PCB board can simply reduce the stray capacitors. Also, the PCB traces should be placed as short as possible in order to reduce parasitic inductance and capacitance. The resistors or loads should be placed as close as possible to the terminals of the SAH2622. The input traces of the SAH2622 should be placed away from the output trace to minimize coupling (crosstalk).

If the SAH2622 is used for differential driver, the customers should guarantee the symmetrical layout to obtain better output performance. If the trace for the differential signal is long, please make sure that place the two differential traces as close as possible, or twist them together in order to reduce the inductive loop. The above method can enhance the anti-interference ability for RF signal by reducing the radiated energy. It is recommended to use strip line for the signal trace which is longer than 1 inch.

Power Dissipation

SAH2622 driver is 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 SAH2622 driver 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.

Input Protection

The input terminal of the SAH2622 is 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 (RI) and/or a feedback resistor (RF) can be used to limit the signal input current. This input series resistor degrades the low-noise performance of the SAH2622 and is examined in the following Noise Performance section. Figure 1 shows an example configuration when both current-limiting input and feedback resistors are used.

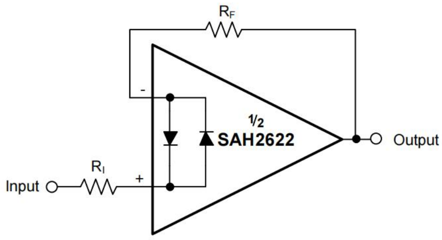


Figure 1. Input Current Limiting

Noise Performance

Equation 1 shows the total circuit noise for varying source impedances with the operational amplifier in a unity-gain configuration(Figure2,no feedback resistor network, and therefore no additional noise contributions).

The SAH2622 (GBP =22MHz, G=+1) is 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 SAH2622 driver makes them a good choice for use in applications where the source impedance is less than 1kΩ . The following equation shows the calculation of the total circuit noise:

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

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

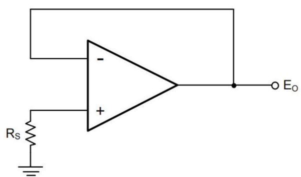
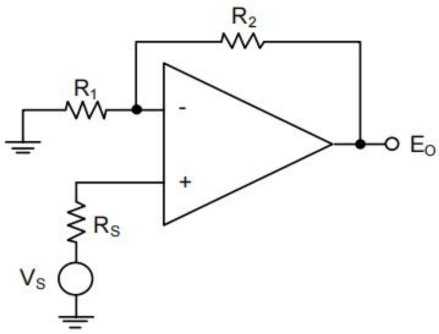


Figure 2. Unity-Gain Buffer Configuration

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:

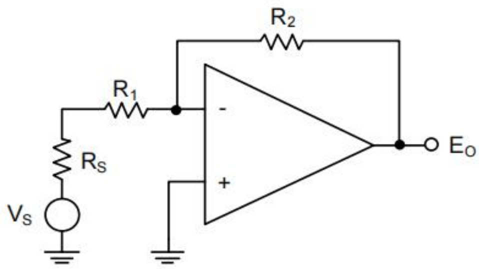
$$E_O^2 = \left[1 + \frac{R_2}{R_1}\right]^2 e_n^2 + e_1^2 + e_2^2 + (i_n R_2)^2 + e_S^2 + (i_n R_S)^2 \left[1 + \frac{R_2}{R_1}\right]^2$$

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

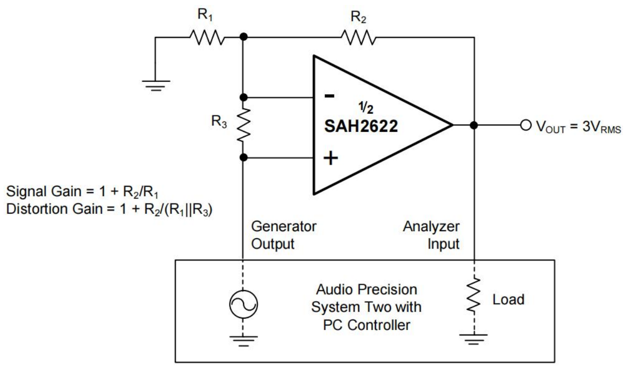
$e_2 = \sqrt{4kTR_2}$ = thermal noise of R_2

NOTE: For the SAH2622 driver at 1kHz, $e_n = 3.5nV/\sqrt{Hz}$ and $i_n = 4pA/\sqrt{Hz}$.

Figure 3. Noise Calculation in Gain Configurations

Total Harmonic Distortion Measurements

The SAH2622 driver has excellent distortion characteristics. THD + noise is below 0.0005% (G = +1, V_{OUT} = 3VRMS, B_W = 80kHz) throughout the audio frequency range, 20Hz to 20kHz, with a 2kΩ load. The distortion produced by SAH2622 driver is below the measurement limit of many commercially available distortion analyzers. However, a special test circuit (such as Figure 4 shows) can be used to extend the measurement capabilities.
Operational amplifier distortion can be considered an internal error source that can be referred to the input. Figure 4 shows a circuit that causes the operational amplifier distortion to be 101 times (or approximately 40dB) greater than that normally produced by the operational amplifier.The addition of R3 to the otherwise standard non-inverting 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 operational amplifier are the same as with conventional feedback without R3. The value of R3 should be kept small to minimize its effect on the distortion measurements.



SIG. GAIN	DIST. 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

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 datasheet 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.

Capacitive Loads

The dynamic characteristics of the SAH2622 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 (RS equal to 50Ω, for example) in series with the output.

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.

Application Circuit

Figure 5 shows how to use the SAH2622 as an amplifier for professional audio headphones. The circuit shows the left side stereo channel. An identical circuit is used to drive the right side stereo channel.

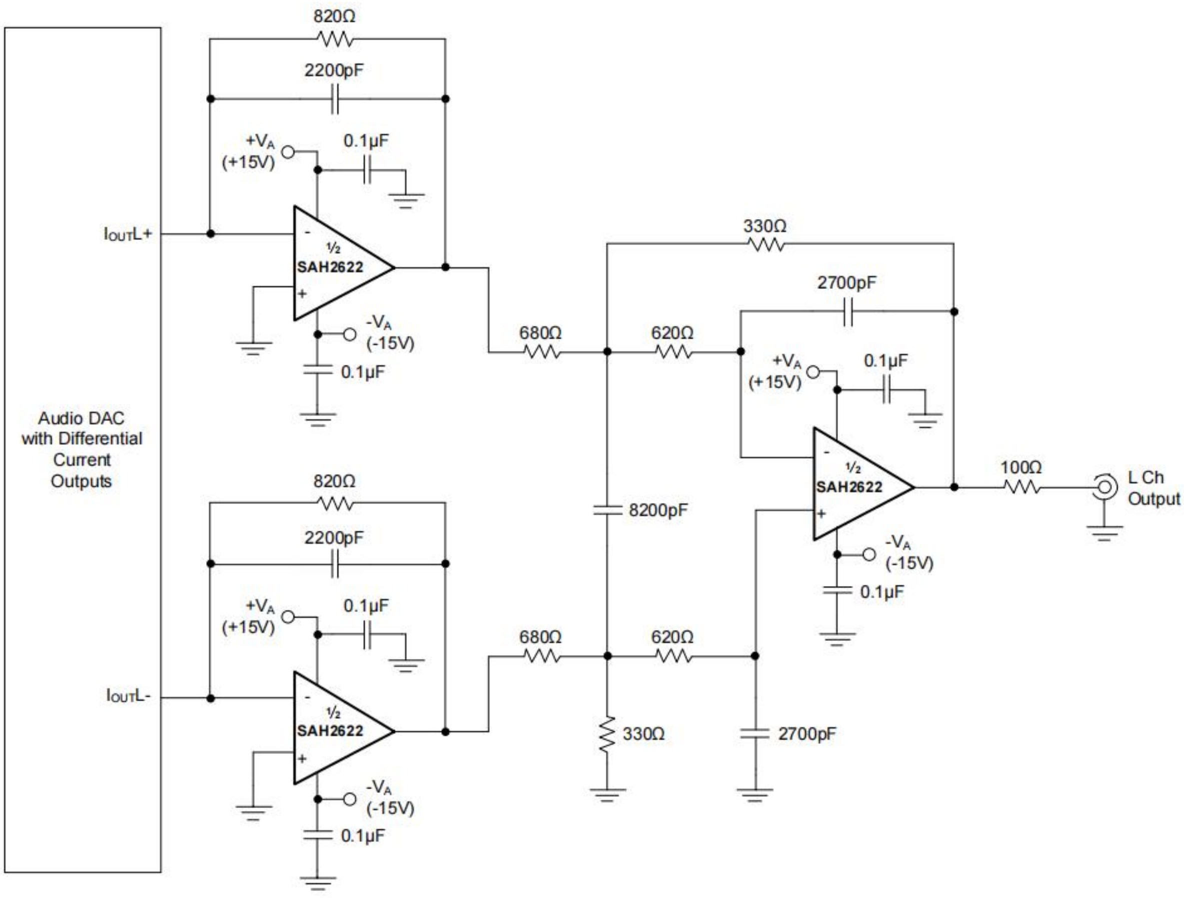
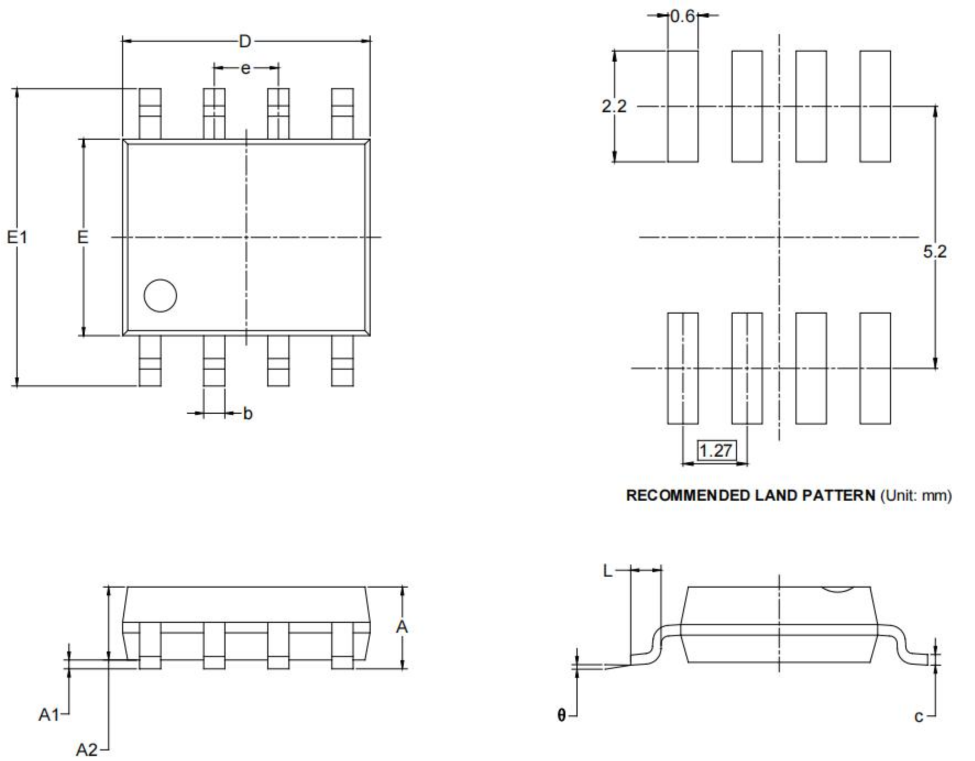


Figure 5. Audio DAC Post Filter (I/V Converter and Low-Pass Filter)

PACKAGE SOP-8



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°

NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

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