HGC8631/HGC8632/HGC8634
470μA, 6MHz, Rail-to-Rail I/O CMOS Operational Amplifier

PRODUCT DESCRIPTION

The HGC8631(single), HGC8632(dual), and HGC8634 (quad) are low noise, low voltage, and low power power operational amplifiers, that can be designed into a wide range of applications. The HGC8631/2/4 have a high gain-bandwidth product of 6MHz, a slew rate of 3.7V/ μs, and a quiescent current of 470μA/amplifier at 5V.

The HGC8631/2/4 are designed to provide optimal performance in low voltage and low noise systems. They provide rail-to-rail output swing into heavy loads. The input common-mode voltage range includes ground, and the maximum input offset voltage are 3.5mV for HGC8631/2/4. They are specified over the extended industrial temperature range (−40°C to +125°C). The operating range is from 2.5V to 5.5V.

The single version, HGC8631, is available in SC70-5, and SOT23-5 packages. The dual version HGC8632 is available in SO-8 and MSOP-8 packages. The quad version HGC8634 is available in SO-16 and TSSOP-16 packages.

APPLICATIONS

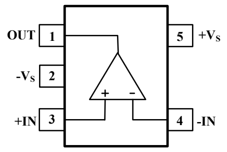
Sensors
Audio
Active Filters
A/D Converters
Communications
Test Equipment
Cellular and Cordless Phones
Laptops and PDAs
Photodiode Amplification
Battery-Powered Instrumentation

FEATURES

- **Low Cost**
- **Rail-to-Rail Input and Output**
  0.8mV Typical V_{OS}
- **High Gain-Bandwidth Product: 6MHz**
- **High Slew Rate: 3.7V/μs**
- **Settling Time to 0.1% with 2V Step: 2.1μs**
- **Overload Recovery Time: 0.9μs**
- **Low Noise : 12 nV/$\sqrt{Hz}$**
- **Operates on 2.5 V to 5.5V Supplies**
- **Input Voltage Range = - 0.1 V to +5.6 V with V_S = 5.5 V**
- **Low Power**
  470μA/Amplifier Typical Supply Current
- **Small Packaging**
  HGC8631 Available in SC70-5, SOT23-5
  HGC8632 Available in MSOP-8 and SO-8
  HGC8634 Available in TSSOP-16 and SO-16

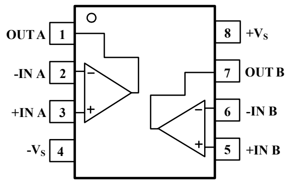
PIN CONFIGURATIONS (Top View)

HGC8631



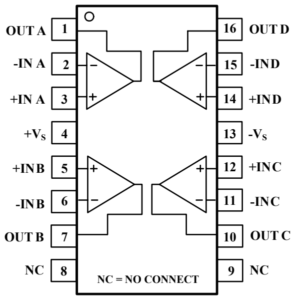
SOT23-5 / SC70-5

HGC8632



SO-8 / MSOP-8

HGC8634



TSSOP-16 / SO-16

ORDERING INFORMATION

DEVICE	Package Type	MARKING	Packing	Packing Qty
HGC8631M5/TR	SOT23-5	C8631	REEL	3000pcs/reel
HGC8631M7/TR	SC70-5	C8631	REEL	3000pcs/reel
HGC8632M/TR	SOP-8L	C8632	REEL	2500pcs/reel
HGC8632MM/TR	MSOP-8L	C8632	REEL	2500pcs/reel
HGC8634M/TR	SOP-16L	HGC8634	REEL	2500pcs/reel
HGC8634MT/TR	TSSOP-16L	C8634	REEL	2500pcs/reel

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V+ to V- .... 7.5 V
Common-Mode Input Voltage
.... $(-V_S) - 0.5$ V to $(+V_S) +0.5$V
Storage Temperature Range..................... –65℃ to +150℃
Junction Temperature...160℃
Operating Temperature Range.................–55℃ to +150℃
Package Thermal Resistance @ $T_A = 25$℃
SC70-5, θ_{JA}... 333℃/W
SOT23-5, θ_{JA}.. 190℃/W
SO-8, θ_{JA}..125℃/W
MSOP-8, θ_{JA}.. 216℃/W
SO-16, θ_{JA}.. 82℃/W
TSSOP-16, θ_{JA}... 105℃/W
Lead Temperature Range (Soldering 10 sec)
....260℃
ESD Susceptibility
HBM..1500V
MM..400V

NOTES

1. Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

CAUTION

This integrated circuit can be damaged by ESD. Shengbang Micro-electronics recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

ELECTRICAL CHARACTERISTICS :V_S = +5V

(At T_A = +25℃, V_{CM} = Vs/2, R_L = 600Ω, unless otherwise noted)

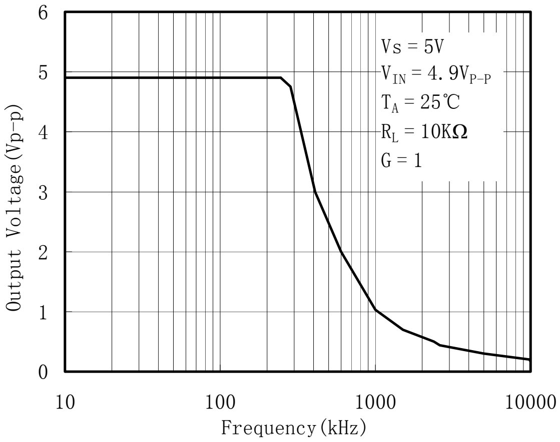
PARAMETER	CONDITION	HGC8631/2/4						
		TYP	MIN/MAX OVER TEMPERATURE					
		+25℃	+25℃	0℃ to 70℃	-40℃ to 85℃	-40℃ to 125℃	UNITS	MIN/ MAX
INPUT CHARACTERISTICS								
Input Offset Voltage (V_{OS})		0.8	3.5	3.9	4.3	4.6	mV	MAX
Input Bias Current (I_B)		1					pA	TYP
Input Offset Current (I_{OS})		1					pA	TYP
Common-Mode Voltage Range (V_{CM})	V_S = 5.5V	-0.1 to +5.6					V	TYP
Common-Mode Rejection Ratio(CMRR)	V_S = 5.5V, V_{CM} = - 0.1V to 4 V	90	75	74	74	73	dB	MIN
	V_S = 5.5V, V_{CM} = - 0.1V to 5.6 V	83					dB	MIN
Open-Loop Voltage Gain(A_{OL})	R_L = 600Ω ,Vo = 0.15V to 4.85V	97	90	87	86	79	dB	MIN
	R_L =10KΩ ,Vo = 0.05V to 4.95V	108					dB	MIN
Input Offset Voltage Drift ($\Delta V_{OS}/\Delta_T$)		2.4					μV/℃	TYP
OUTPUT CHARACTERISTICS								
Output Voltage Swing from Rail	R_L = 600Ω	0.1					V	TYP
	R_L = 10KΩ	0.015					V	
Output Current (I_{OUT})		53	49	45	40	35	mA	MIN
Closed-Loop Output Impedance	F = 200KHz, G = 1	3					Ω	TYP
POWER-DOWN DISABLE								
Turn-On Time		4					μs	TYP
Turn-Off Time		1.2					μs	TYP
$\overline{DISABLE}$ Voltage-Off			0.8				V	MAX
$\overline{DISABLE}$ Voltage-On			2				V	MIN
POWER SUPPLY								
Operating Voltage Range			2.5	2.5	2.5	2.5	V	MIN
			5.5	5.5	5.5	5.5	V	MAX
Power Supply Rejection Ratio (PSRR)	V_s = +2.5 V to + 5.5 V							
	V_{CM} = (-V_S) + 0.5V	91	80	78	78	77	dB	MIN
Quiescent Current/ Amplifier (I_Q)	I_{OUT} = 0	470	590	660	680	740	μA	MAX
Supply Current when Disabled (SGM8633 only)		90					nA	MAX
DYNAMIC PERFORMANCE								
Gain-Bandwidth Product (GBP)	R_L = 10KΩ	6					MHz	TYP
Phase Margin(φ_O)		60					degrees	TYP
Full Power Bandwidth(BW_P)	＜1% distortion, R_L = 600Ω	250					KHz	TYP
Slew Rate (SR)	G = +1 , 2V Step, R_L = 10KΩ	3.7					V/μs	TYP
Settling Time to 0.1%(t_S)	G = +1, 2 V Step, R_L = 600Ω	2.1					μs	TYP
Overload Recovery Time	V_{IN} ·Gain = Vs, R_L = 600Ω	0.9					μs	TYP
NOISE PERFORMANCE								
Voltage Noise Density (e_n)	f = 1kHz	12					nV/$\sqrt{Hz}$	TYP
Current Noise Density(i_n)	f = 1kHz	3					fA/$\sqrt{Hz}$	TYP

Specifications subject to change without notice.

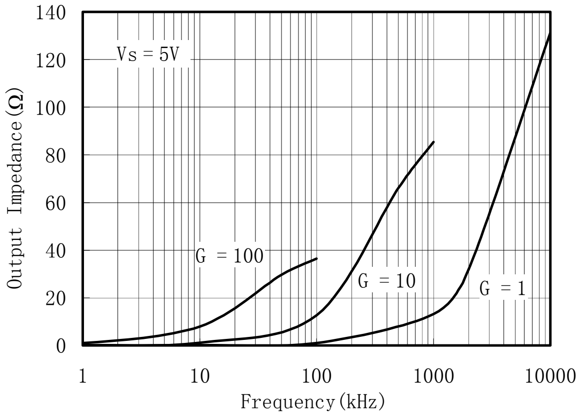
TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃,V_{CM} = Vs/2, R_L = 600Ω, unless otherwise noted.

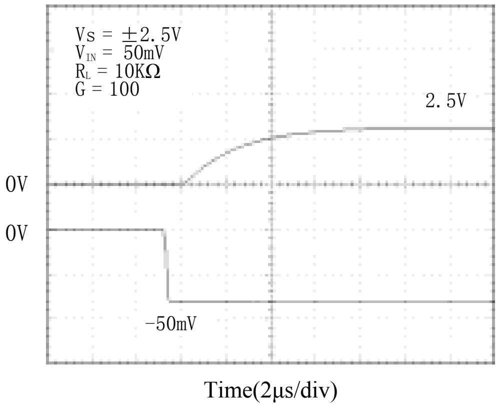
Closed-Loop Output Voltage Swing



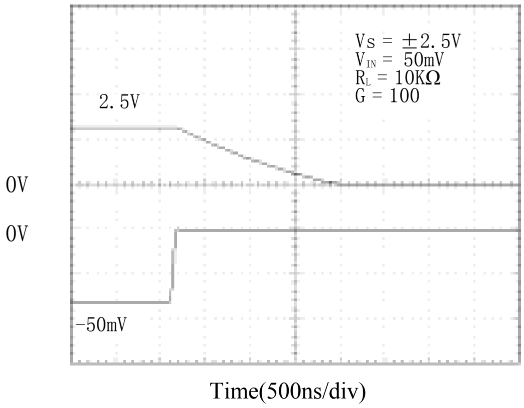
Output Impedance vs. Frequency



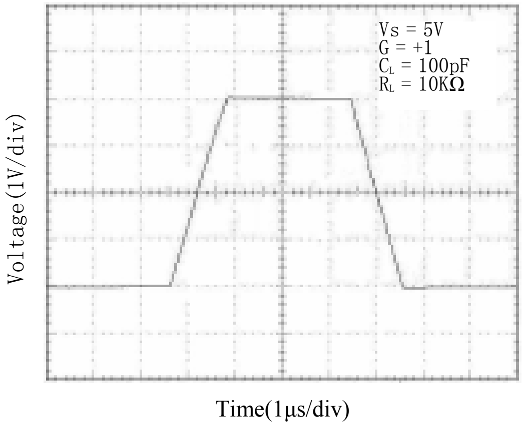
Positive Overload Recovery



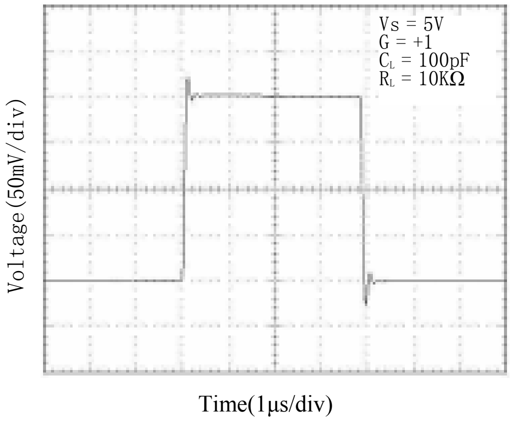
Negative Overload Recovery



Large-Signal Step Response

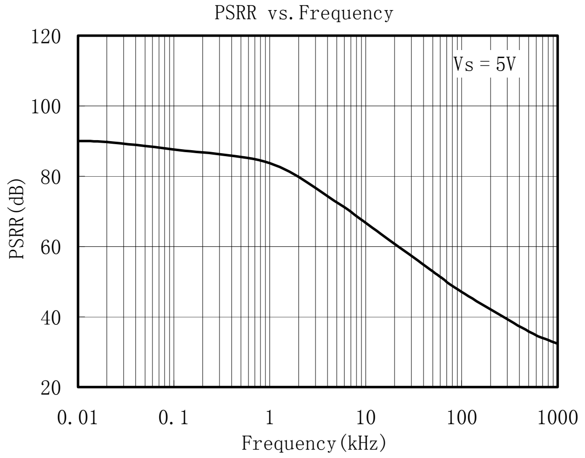


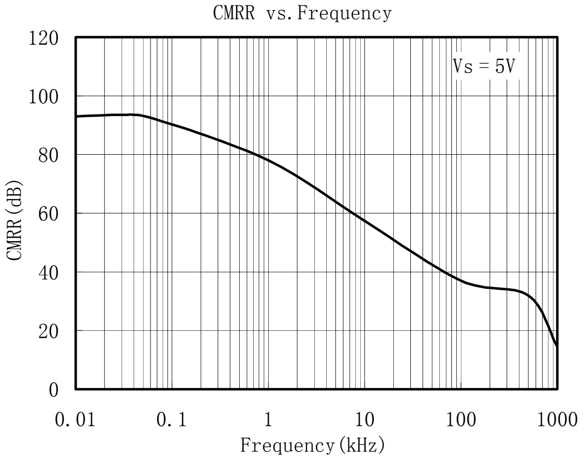
Small-Signal Step Response

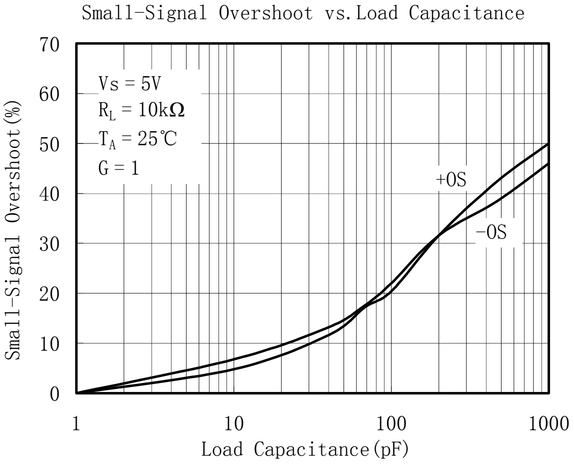


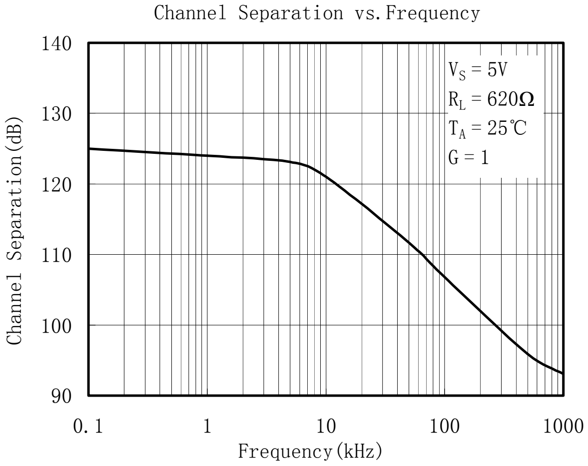
TYPICAL PERFORMANCE CHARACTERISTICS

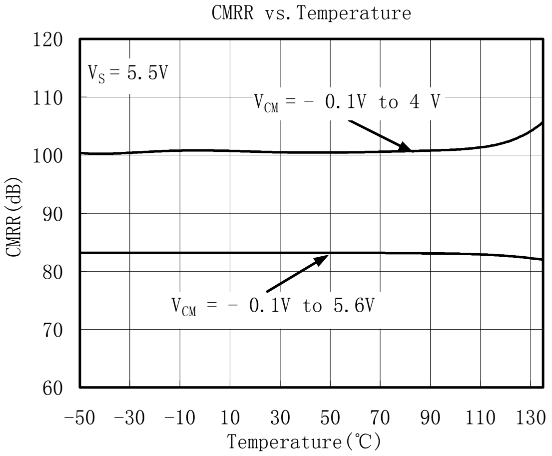
At T_A = +25℃,V_{CM} = Vs/2, R_L = 600Ω, unless otherwise noted.

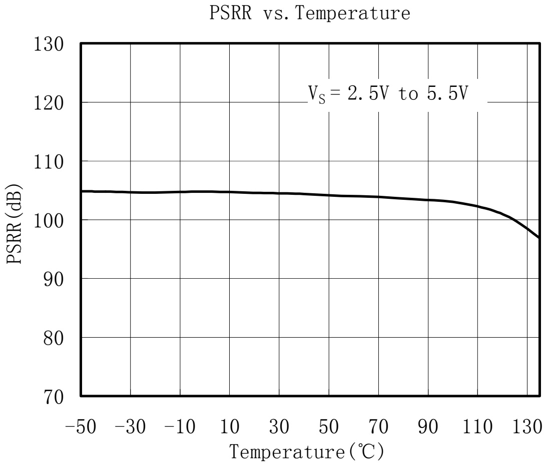






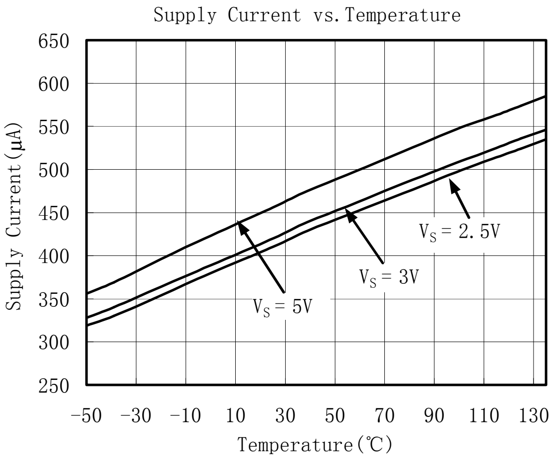


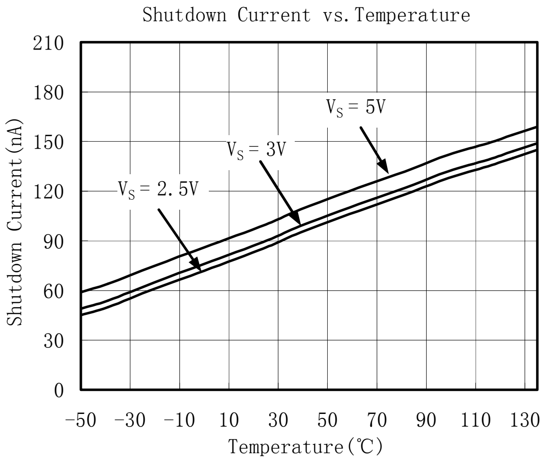


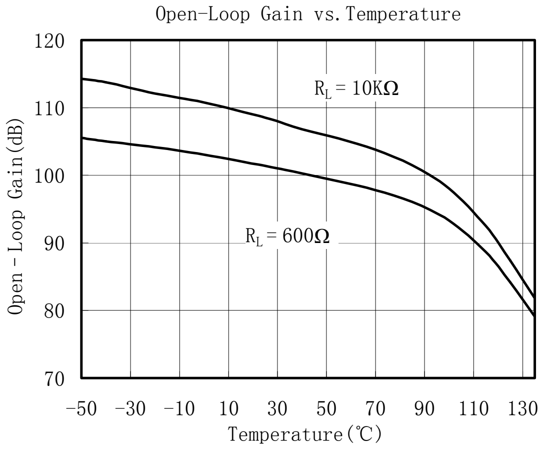


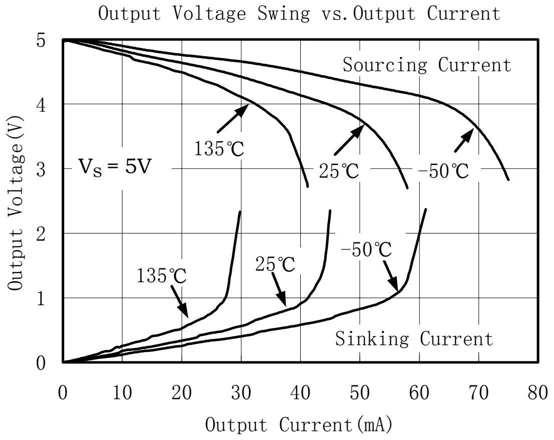
TYPICAL PERFORMANCE CHARACTERISTICS

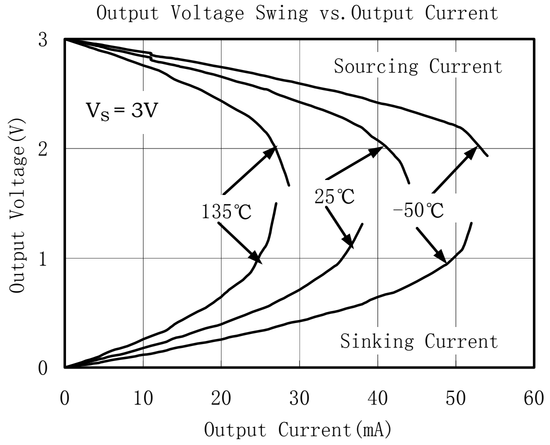
At T_A = +25℃,V_{CM} = Vs/2, R_L = 600Ω, unless otherwise noted.

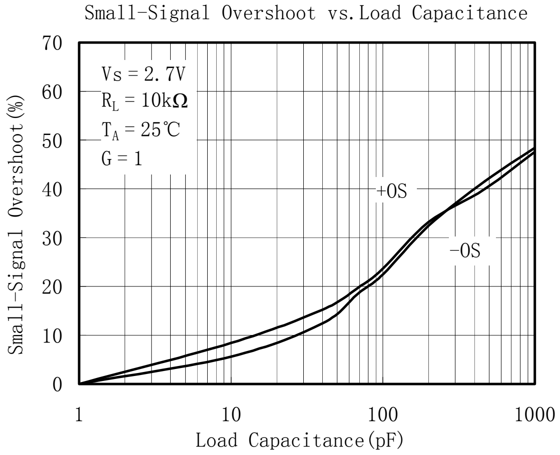

Supply Current vs. Temperature


Shutdown Current vs. Temperature


Open-Loop Gain vs. Temperature

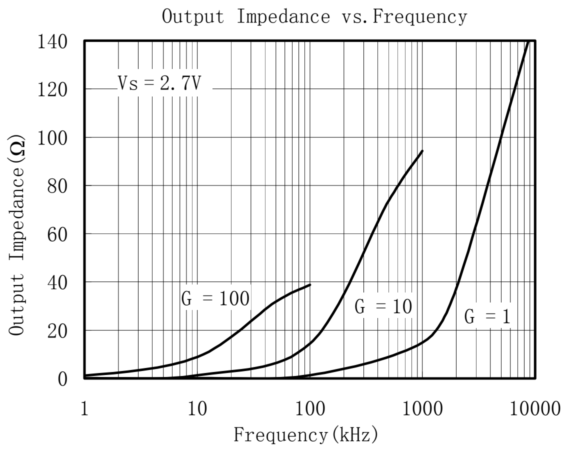

Output Voltage Swing vs. Output Current

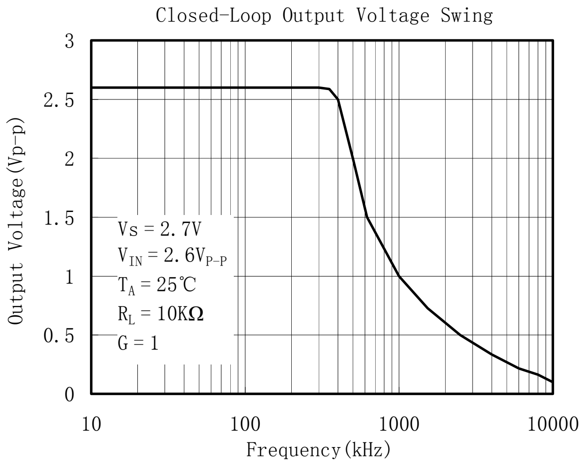

Output Voltage Swing vs. Output Current

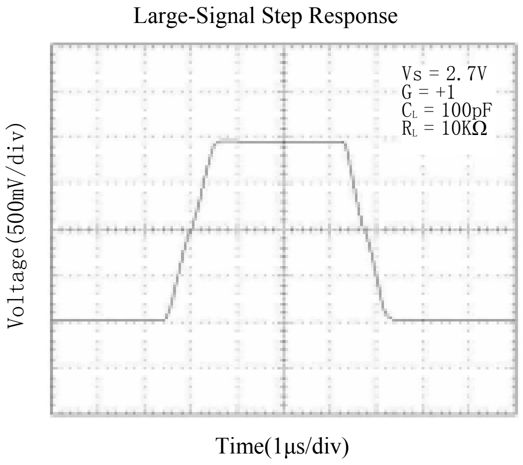

Small-Signal Overshoot vs. Load Capacitance

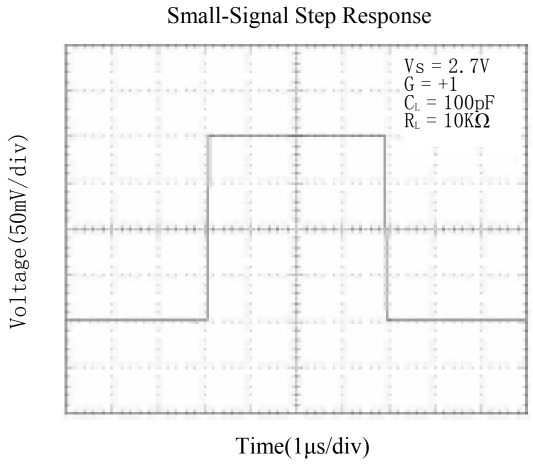
TYPICAL PERFORMANCE CHARACTERISTICS

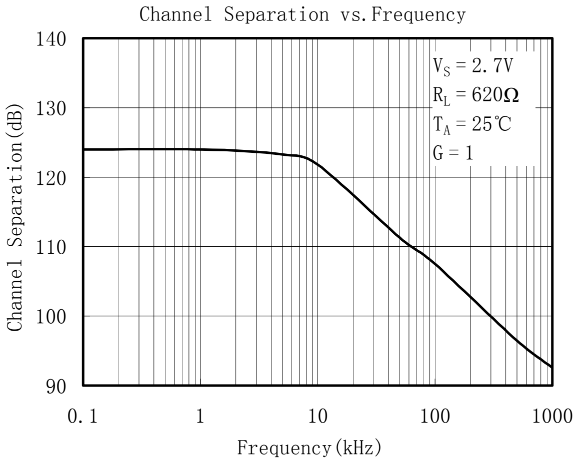
At T_A = +25℃,V_{CM} = Vs/2, R_L = 600Ω, unless otherwise noted.

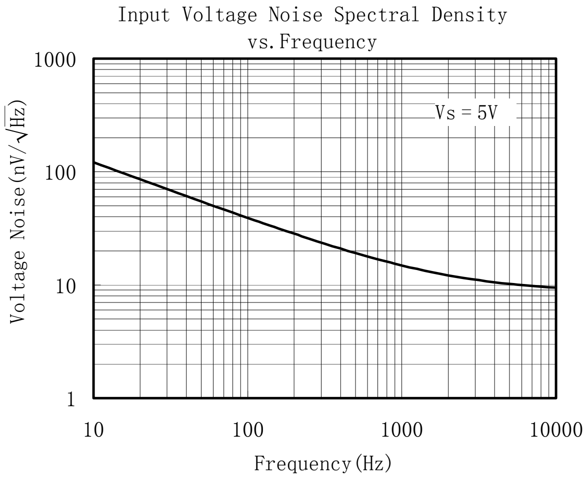












TYPICAL PERFORMANCE CHARACTERISTICS

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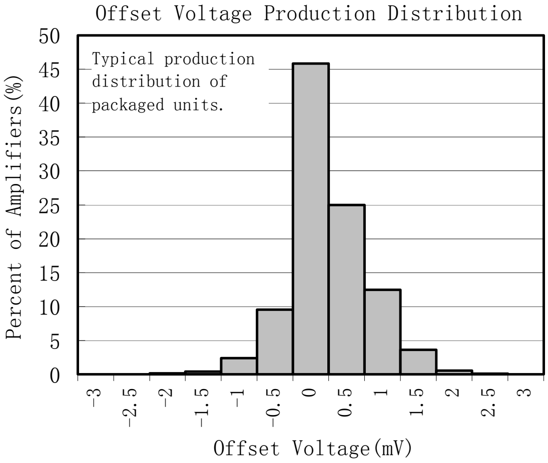


APPLICATION NOTES

Driving Capacitive Loads

The HGC863x can directly drive 1000pF in unity-gain without oscillation. The unity-gain follower (buffer) is the most sensitive configuration to capacitive loading. Direct capacitive loading reduces the phase margin of amplifiers and this results in ringing or even oscillation. Applications that require greater capacitive drive capability should use an isolation resistor between the output and the capacitive load like the circuit in Figure 1. The isolation resistor R_{ISO} and the load capacitor C_L form a zero to increase stability. The bigger the R_{ISO} resistor value, the more stable V_{OUT} will be. Note that this method results in a loss of gain accuracy because R_{ISO} forms a voltage divider with the R_{LOAD}.

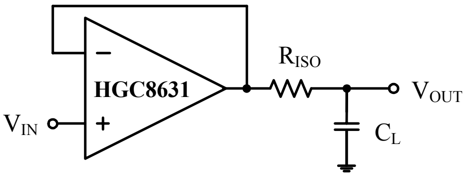


Figure 1. Indirectly Driving Heavy Capacitive Load

An improvement circuit is shown in Figure 2. It provides DC accuracy as well as AC stability. R_F provides the DC accuracy by connecting the inverting signal with the output. C_F and R_{Iso} serve to counteract the loss of phase margin by feeding the high frequency component of the output signal back to the amplifier's inverting input, thereby preserving phase margin in the overall feedback loop.

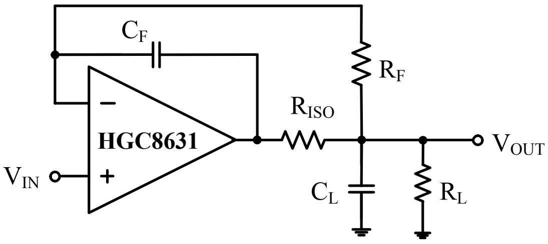


Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy

For no-buffer configuration, there are two others ways to increase the phase margin: (a) by increasing the amplifier's gain or (b) by placing a capacitor in parallel with the feedback resistor to counteract the parasitic capacitance associated with inverting node.

Power-Supply Bypassing and Layout

The HGC863x family operates from either a single +2.5V to +5.5V supply or dual ±1.25V to ±2.75V supplies. For single-supply operation, bypass the power supply V_{DD} with a 0.1μF ceramic capacitor which should be placed close to the V_{DD} pin. For dual-supply operation, both the V_{DD} and the V_{SS} supplies should be bypassed to ground with separate 0.1μF ceramic capacitors. 2.2μF tantalum capacitor can be added for better performance.

Good PC board layout techniques optimize performance by decreasing the amount of stray capacitance at the op amp's inputs and output. To decrease stray capacitance, minimize trace lengths and widths by placing external components as close to the device as possible. Use surface-mount components whenever possible.

For the operational amplifier, soldering the part to the board directly is strongly recommended. Try to keep the high frequency big current loop area small to minimize the EMI (electromagnetic interfacing).

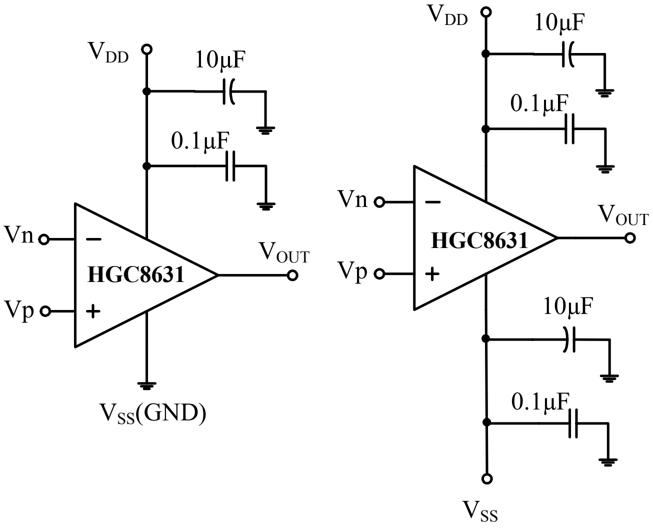


Figure 3. Amplifier with Bypass Capacitors

Grounding

A ground plane layer is important for HGC863x circuit design. The length of the current path speed currents in an inductive ground return will create an unwanted voltage noise. Broad ground plane areas will reduce the parasitic inductance.

Input-to-Output Coupling

To minimize capacitive coupling, the input and output signal traces should not be parallel. This helps reduce unwanted positive feedback.

Typical Application Circuits

Differential Amplifier

The circuit shown in Figure 4 performs the difference function. If the resistors ratios are equal (R4 / R3 = R2 / R1), then V_{OUT} = (Vp – Vn) × R_2 / R_1 + Vref.

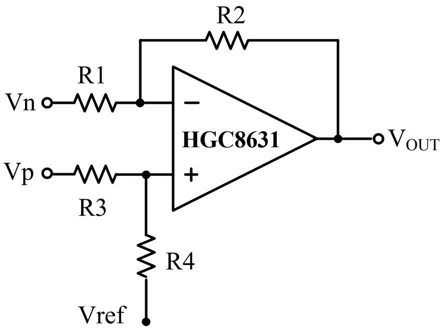


Figure 4. Differential Amplifier

Instrumentation Amplifier

The circuit in Figure 5 performs the same function as that in Figure 4 but with the high input impedance.

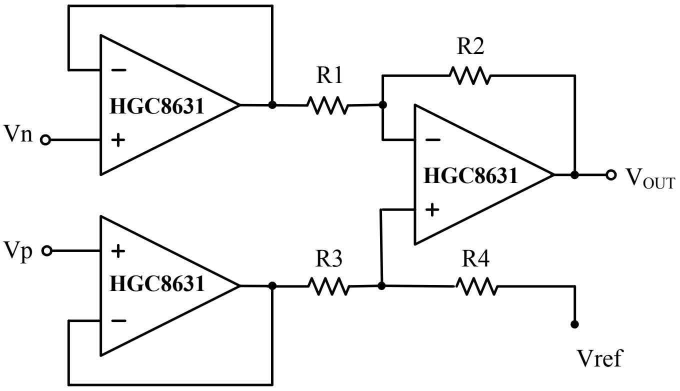


Figure 5. Instrumentation Amplifier

Low Pass Active Filter

The low pass filter shown in Figure 6 has a DC gain of ($-R_2/R_1$) and the –3dB corner frequency is $1/2\pi R_2C$. Make sure the filter is within the bandwidth of the amplifier. The Large values of feedback resistors can couple with parasitic capacitance and cause undesired effects such as ringing or oscillation in high-speed amplifiers. Keep resistors value as low as possible and consistent with output loading consideration.

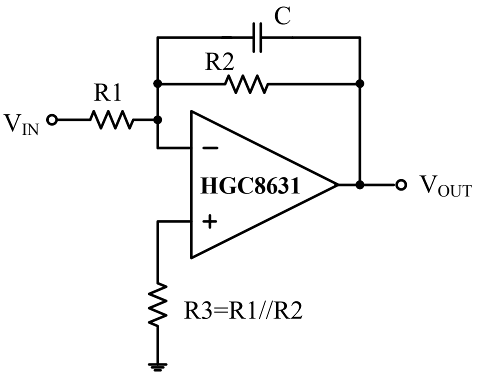
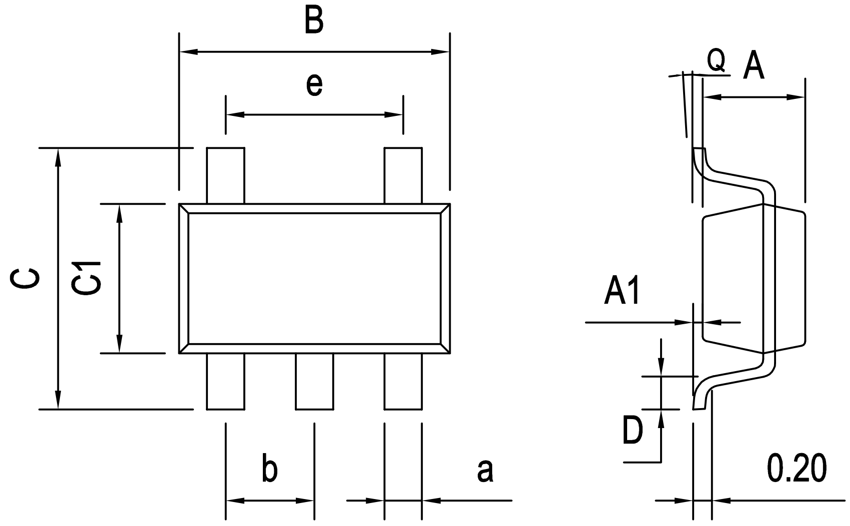


Figure 6. Low Pass Active Filter

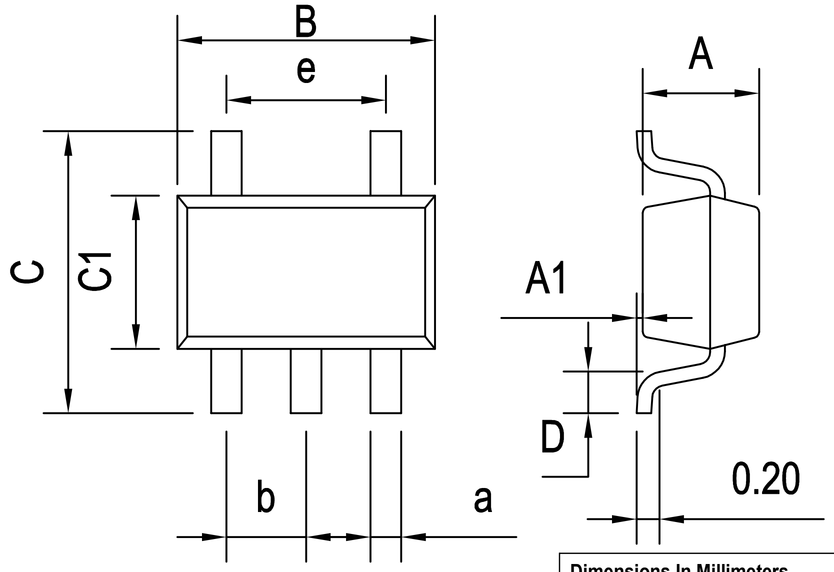
PACKAGE

SOT23-5



Dimensions In Millimeters					
Symbol :	**Min :**	**Max :**	**Symbol :**	**Min :**	**Max :**
A	1.050	1.150	**D**	0.300	0.600
A1	0.000	0.100	**Q**	0°	8°
B	2.820	3.020	**a**	0.400 TYP	
C	2.650	2.950	**b**	0.950 TYP	
C1	1.500	1.700	**e**	1.900 TYP	

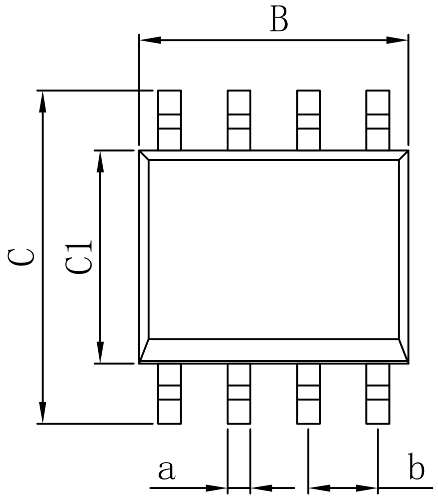
SC70-5

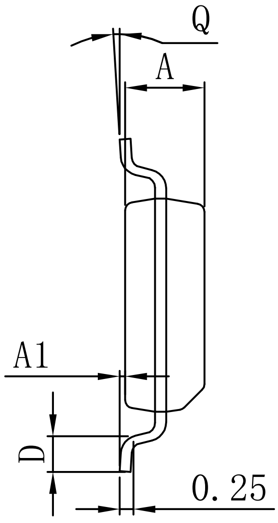


Dimensions In Millimeters					
Symbol :	**Min :**	**Max :**	**Symbol :**	**Min :**	**Max :**
A	0.900	1.000	**D**	0.260	0.460
A1	0.000	0.100	**Q**	0°	8°
B	2.000	2.200	**a**	0.250 TYP	
C	2.150	2.450	**b**	0.650 TYP	
C1	1.150	1.350	**e**	1.300 TYP	

PACKAGE

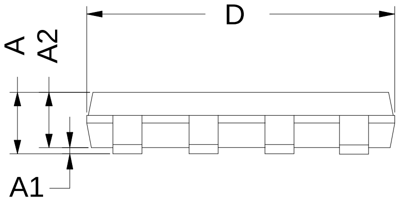
SOP8

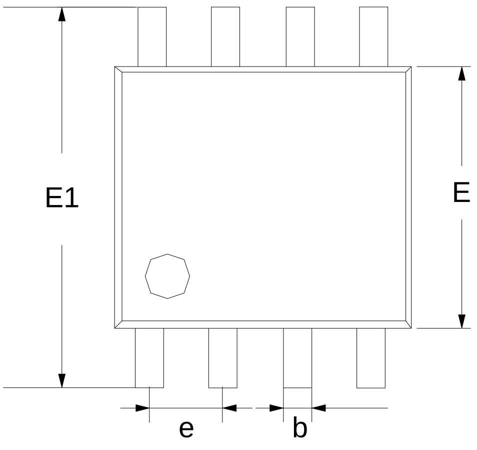


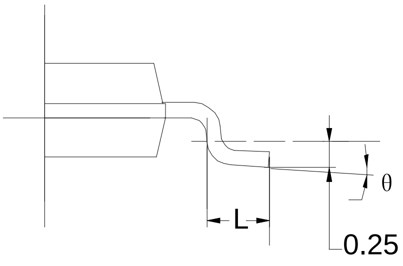


Dimensions In Millimeters					
Symbol :	**Min :**	**Max :**	**Symbol :**	**Min :**	**Max :**
A	1.225	1.570	**D**	0.400	0.950
A1	0.100	0.250	**Q**	0°	8°
B	4.800	5.100	**a**	0.420 TYP	
C	5.800	6.250	**b**	1.270 TYP	
C1	3.800	4.000			

MSOP8



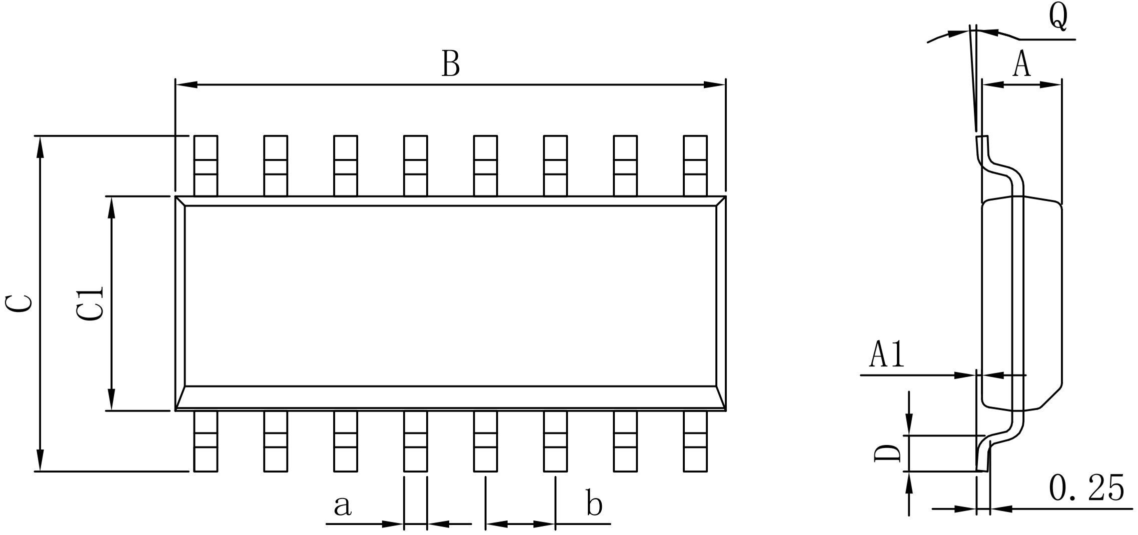




Dimensions In Millimeters					
Symbol :	**Min :**	**Max :**	**Symbol :**	**Min :**	**Max :**
A	0.800	1.200	**E1**	4.700	5.100
A1	0	0.200	**L**	0.410	0.650
A2	0.760	0.970	**θ**	0°	6°
D	2.900	3.100	**b**	0.300 TYP	
E	2.900	3.100	**e**	0.650 TYP	

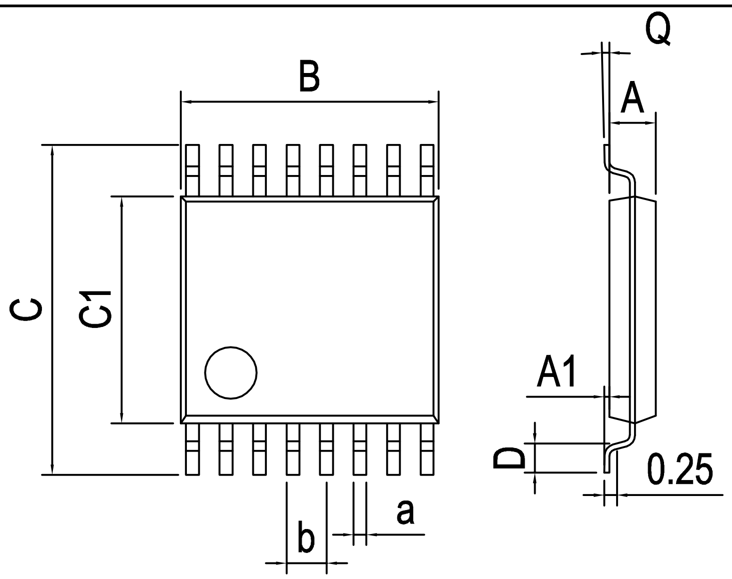
PACKAGE

SOP16



Dimensions In Millimeters					
Symbol :	**Min :**	**Max :**	**Symbol :**	**Min :**	**Max :**
A	1.225	1.570	**D**	0.400	0.950
A1	0.100	0.250	**Q**	0°	8°
B	9.800	10.00	**a**	0.420 TYP	
C	5.800	6.250	**b**	1.270 TYP	
C1	3.800	4.000			

TSSOP16



Dimensions In Millimeters					
Symbol :	**Min :**	**Max :**	**Symbol :**	**Min :**	**Max :**
A	0.800	1.000	**D**	0.400	0.850
A1	0.050	0.150	**Q**	0°	8°
B	4.900	5.100	**a**	0.240 TYP	
C	6.250	6.550	**b**	0.650 TYP	
C1	4.300	4.500			

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