50MHz, Zero-Crossover, Low-Distortion, High CMRR, RRI/O, Single-Supply Operational Amplifier

Features

- High Gain Bandwidth: 50MHz
- Slew Rate: 40V/μ s
- Fast Settling: 270ns to 0.01%
- Low Noise: 4.4uVpp at 0.1Hz ~10Hz
- Rail-to-Rail Input and Output
- Zero-Crossover Distortion Topology:
  CMRR: 100 dB (TYP)
- Supply Voltage Range: 2.2V to 5.5V
- Precision:
  Low Offset: 100uV (TYP)
  Low Input Bias Current: 50pA (TYP
- Operating Temperature: -40'C to +125'C
- Available in Green SOT23-5, MSOP8 SOIC-8(SOP-8) and SOIC-14(SOP-14)

Applications

- Signal Conditioning
- Data Acquisition
- Process Control
- Active Filters
- Test Equipment
- Audio
- Wideband Amplifiers

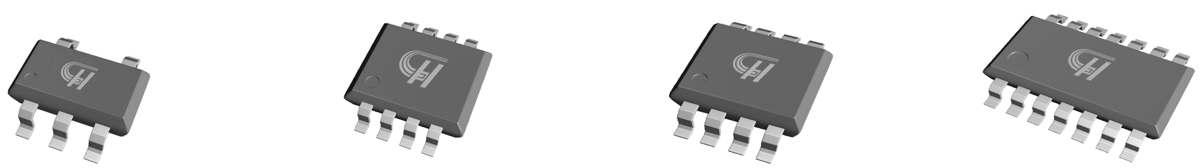
General Description [note a]

The HCR8701(single) /HCR8702(dual) /HCR8704(quad) are zero-crossover series, rail-to-rail, high performance, CMOS operational amplifiers are optimized for very low voltage, single-supply applications. Rail-to-rail input or output, low-noise(4.4uVpp) and high-speed operation (50MHz Gain Bandwidth) make these devices ideal for driving sampling analog-to-digital converters (ADCs).

Applications include audio, signal conditioning, and sensor amplification. The HCR8701/HCR8702/HCR8704 of op-amps are also well-suited for cell phone power amplifier control loops.

Special features include an excellent common-mode rejection ratio (CMRR), no input stage crossover distortion, high input impedance, and rail-to-rail input and output swing. The input common mode range includes both the negative and positive supplies.

The devices are ideal for sensor interfaces, active filters and portable applications.The HCR8701/HCR8702/HCR8704 families of operational amplifiers are specified at the full temperature range of -40°C to +125°C. under single or dual power supplies of 2.2V to 5.5V.



SOT23-5 MSOP-8 SOIC-8(SOP-8) SOIC-14(SOP-14)

Figure 1. Package Type of HCR8701/HCR8702/HCR8704

50MHz, Zero-Crossover, Low-Distortion, High CMRR, RRI/O, Single-Supply Operational Amplifier

Pin Configuration

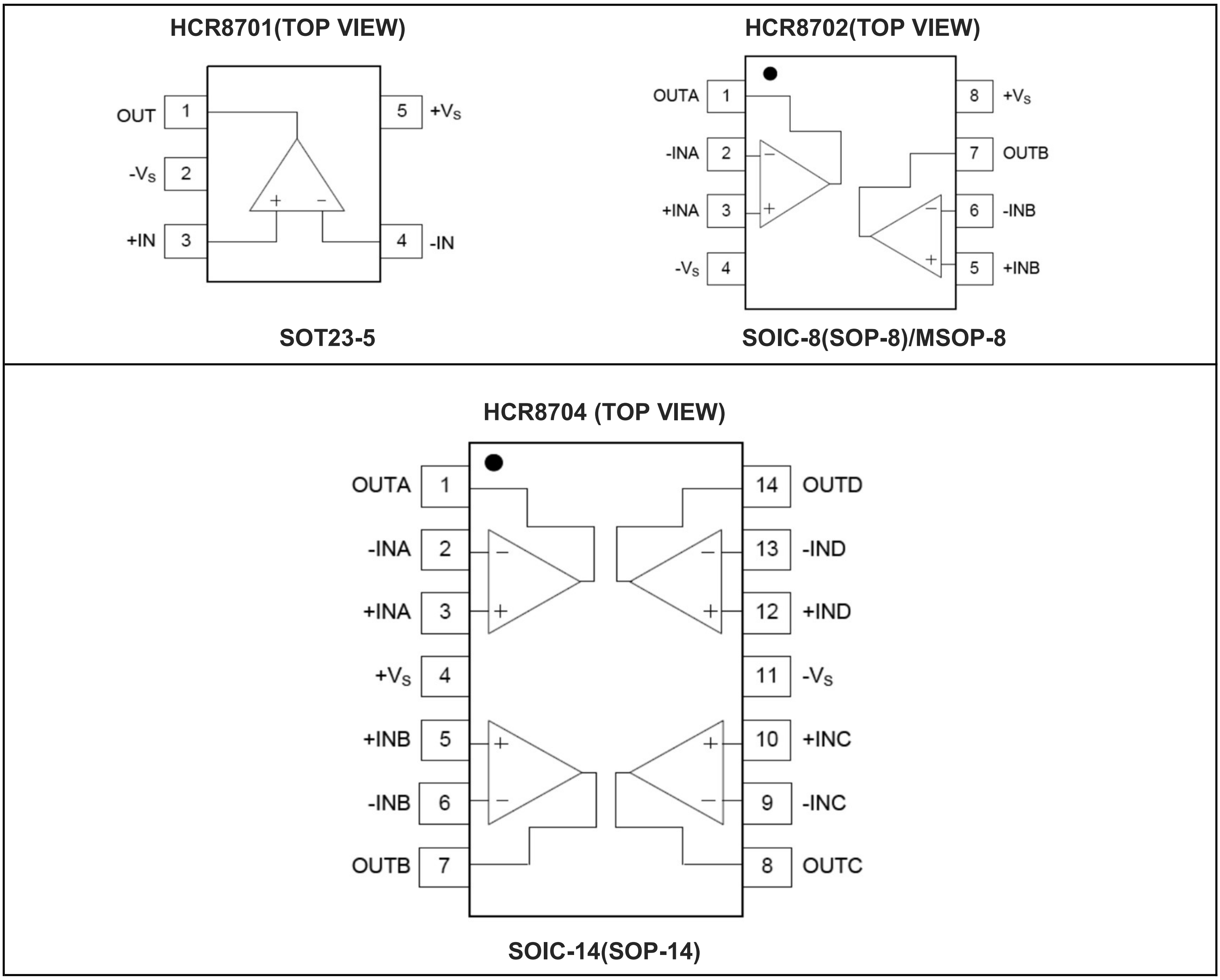


Figure 2. Pin Configuration of HCR8701/HCR8702/HCR8704(Top View)

Pin Function Table

Name	Function
+IN, +INA, +INB, +INC, +IND	Non-inverting Inputs
-IN, -INA, -INB, -INC, -IND	Inverting Inputs
+Vs	Positive(highest) Power Supply
-Vs	Negative(lowest) Power Supply
OUT, OUTA, OUTB, OUTC, OUTD	Outputs

Ordering Information

Circuit Type / □ □

Type:
HCR8701
HCR8702
HCR8704

TR : Tape and Reel

Package:
M5:SOT23-5
SM8:MSOP-8
M8: SOIC-8(SOP8)
M14: SOIC-14(SOP-14)

Ordering Code

Part Number	Channel	Marking [1]	Op Temp('C)	MSL [2]	Package	Package Qty
HCR8701/M5TR	1	8701	-40'C to +125'C	MSL3	SOT23-5	3000pcs/TR
HCR8702/SM8TR	2	HCR8702xx	-40'C to +125'C	MSL3	MSOP-8	4000pcs/TR
HCR8702/M8TR	2	HCR8702xx	-40'C to +125'C	MSL3	SOIC-8 (SOP-8)	4000pcs/TR
HCR8704/M14TR	4	HCR8704xx	-40'C to +125'C	MSL3	SOIC-14 (SOP-14)	2500pcs/TR

note 1: There may be additional marking, which relates to the lot trace code information(data code and vendor code)， the logo or the environmental category on the device.

2: HCRSEMI classify the MSL level with using the common preconditioning setting in our assembly factory conforming to the JEDEC industrial standard J-STD-20F. Please align with HCRSEMI if your end application is quite critical to the preconditioning setting or if you have special requirement.

Absolute Maximum Ratings

Over operating free-air temperature range(unless otherwise noted) (1)

Parameter		Symbol	Value	Unit
Supply Voltage, +Vs to -Vs		V+	+5.5	V
Signal Input Voltage		VIN	(V-)-0.5 to (V+)+0.5	V
Signal Output Voltage		Vout	(V-)-0.5 to (V+)+0.5	V
Signal Input Current		IIN	-10 to +10	mA
Output Short-circuit (3)		-	Continuous	
Thermal Resistance (4) @TA=+25'C	SOT23-5	θJA	230	'C/W
	SOIC-8	θJA	110	'C/W
	MSOP-8	θJA	165	'C/W
	SOIC-14	θJA	105	'C/W
Storage Temperature Range		TSTG	-65 to +150	'C
Operating Temperature Range note 2		TOPR	-40 to +125	'C
Junction Temperature (5)		TJ	+150	'C
Lead Temperature (Soldering, 10s)		TLEAD	260	'C
Human Body Model ESD Protection		ESD HBM	4	KV
Machine Model ESD Protection		ESD MM	400	V

Note 1. Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.

2. Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current-limited to 10mA or less.

3. Short-circuit to ground, one amplifier per package.

4. The package thermal impedance is calculated in accordance with JESD-51.

5. The maximum power dissipation is a function of TJ(MAX), RθJA, and TA. The maximum allowable power dissipation at any ambient temperature is PD = (T J(MAX) - TA) / RθJA. All numbers apply for packages soldered directly onto a PCB.

Recommended Operating Conditions

Parameter		Symbol	Min.	Max.	Unit
Supply Voltage, +Vs to -Vs	Signal-supply	VIN	2.2	5.5	V
	Dual-supply		±1.1	±2.75	V
Operating Temperature Range		Ta	-40	+125	'C

50MHz, Zero-Crossover, Low-Distortion, High CMRR, RRI/O, Single-Supply Operational Amplifier

Electrical Characteristics

(TA=25 `C, Vs=2.2V to +5.5V, RL=10KΩ connected to 0V, VCM=Vs/2, VOUT=0V. Full=-40'C to 125'C, Unless Otherwise Specified.)

Parameter	Symbol	Conditions	TEMP	Min	Type	Max	Unit
Input Characteristics							
Input Offset Voltage	V_{OS}	V_{CM} =V_S /2	25'C	-200	±100	200	uV
Input Offset Voltage Average Drift	$\Delta V_{OS}/\Delta T$		Full	-	±1.6	-	uV/'C
Power Supply Rejection Ratio	PSRR	Vs=2.2V to 5.5V	25'C	85	107	-	dB
			Full	-	103	-	
Input Bias Current:	I_B		25'C	-	50	500	pA
			Full	-	500	-	pA
Input Offset Current:	I_{OS}		25'C	-	50	500	pA
			Full	-	500	-	pA
Common-Mode Voltage Range	V_{CM}		Full	(V-)	-	(V+) +0.1	V
Common Mode Rejection Ratio	CMRR	Vs=5.5V, (V-)<V_{CM}<(V+)	25'C	85	100	-	dB
			Full	-	100	-	
Open-Loop Voltage Gain	A_{OL}	V_S=5V, R_L=10KΩ, Vout=(V-)+0.15V to (V+)-0.15V	25'C	101	124	-	dB
			Full	-	120	-	dB
Output Characteristics							
Output Voltage Swing from Rail	V_{OH}	V_S=5V, R_L=2KΩ	25'C	-	7	16	mV
	V_{OL}		25'C	-	21	30	
Output Source Current	I_{SOURCE}	Vs=5V	25'C	90	150	-	mA
Output Sink Current	I_{SINK}		25'C	50	118	-	
Power Supply							
Operating Voltage Range	V_S		Full	2.2	-	5.5	V
Quiescent Current per Amplifier	I_Q	I_{OUT}=0mA	25'C	-	7	10	mA
		I_{OUT}=0mA	Full	-	-	12	
Dynamic Performance							
Gain Bandwidth Product	GBP	V_{IN}=50mV$_{p-p}$	25'C	-	50	-	MHz
Phase Margin	$Ø_O$	V_{OUT}=100mV$_{p-p}$ C_L=70pF	25'C	-	60	-	o
Slew Rate	SR	G=+1	25'C	-	40	-	V/uS
Settling Time to 0.01%	ts	V_S=5V, V_{pp}=4V, G=+1, C_L=100pF	25'C	-	270	-	nS
Overload Recovery Time	t_{OR}	V_{IN}xG>=V_S	25'C	-	54	-	nS
Noise Performance							
Input Voltage Noise	e_{np-p}	f=0.1Hz to 10Hz	25'C	-	4.4	-	nVpp
Input Voltage Noise Density	en	f=100KHz	25'C	-	4	-	nV/ √Hz

Typical Performance Characteristics.

(at TA=25'C, Vs=+5V, Unless Otherwise Noted.)

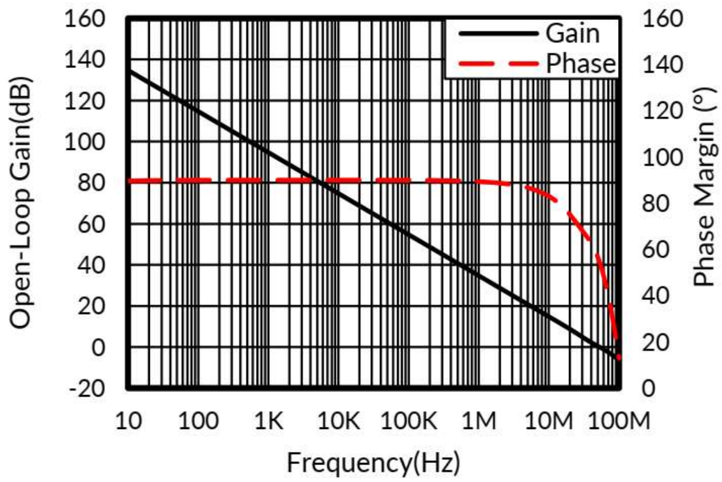


Figure 3. Open-Loop Gain and Phase vs Frequency

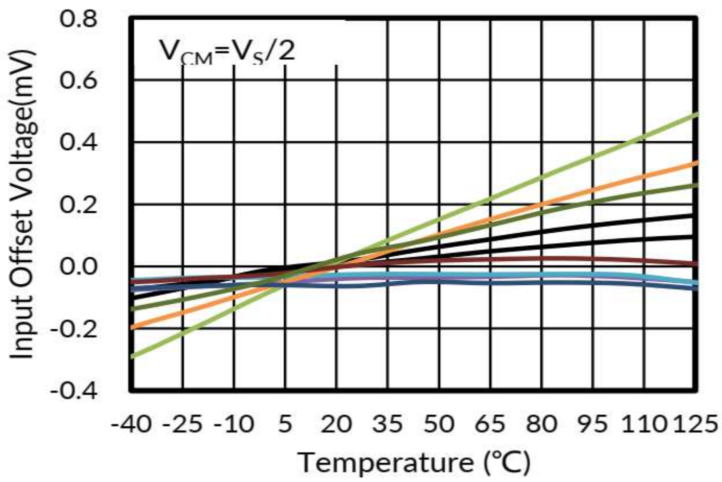


Figure 4. Input Offset Voltage vs Temperature

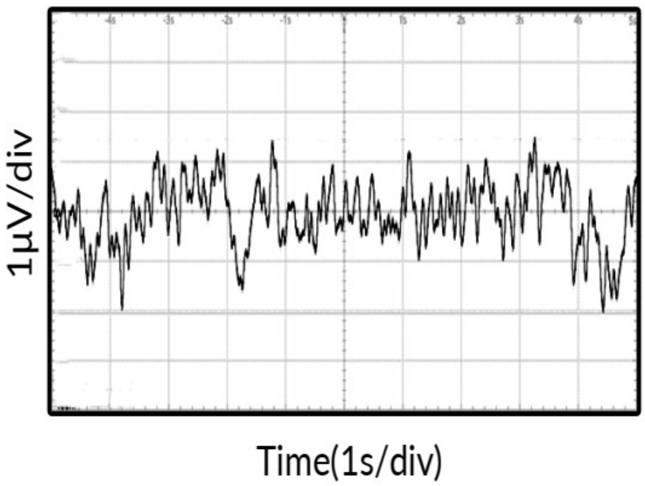


Figure 5. 0.1Hz to 10Hz Input Voltage Noise

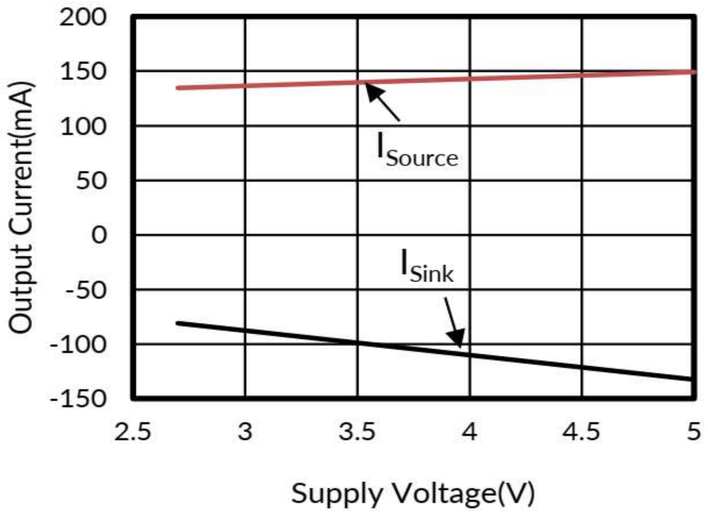


Figure 6. Supply Voltage vs Output Current

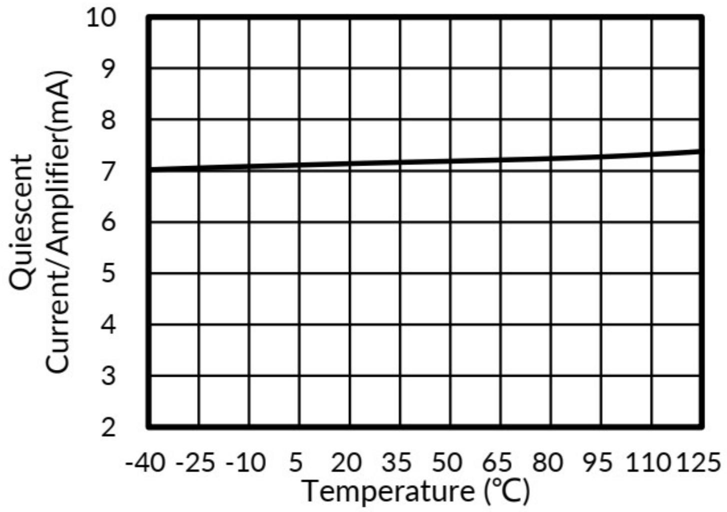


Figure 7. Quiescent Current vs Temperature

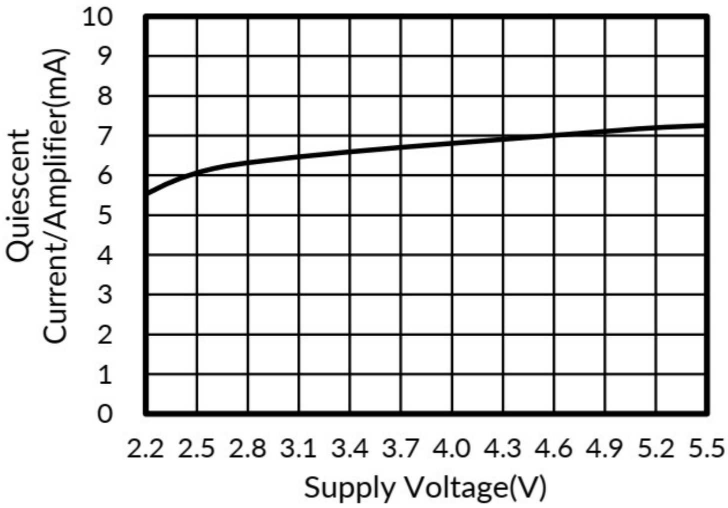


Figure 8. Quiescent Current vs Temperature

Typical Performance Characteristics(con.)

(at TA=25'C, Vs=+5V, Unless Otherwise Noted.)

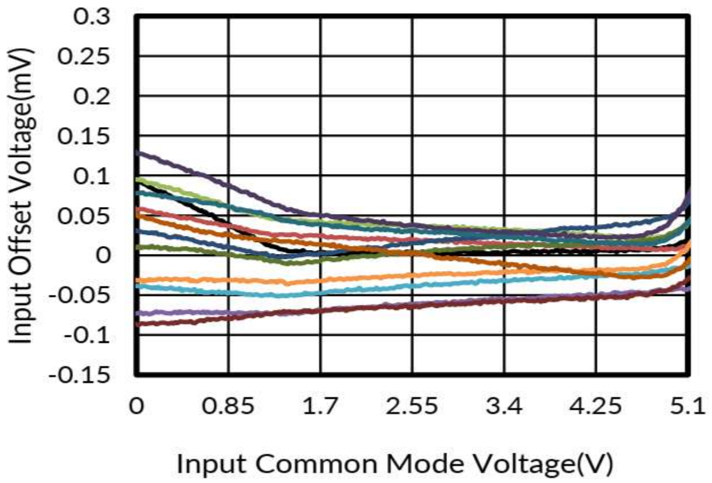


Figure 9. Input Offset Voltage vs Input Common Mode Voltage

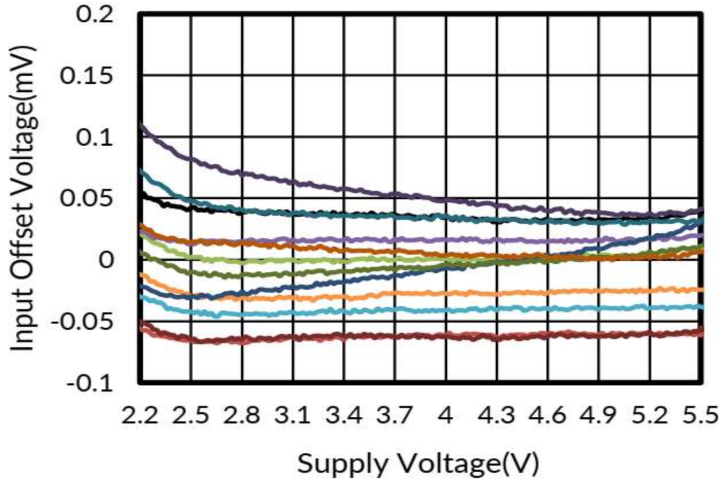


Figure 10. Input Offset Voltage vs Supply Voltage

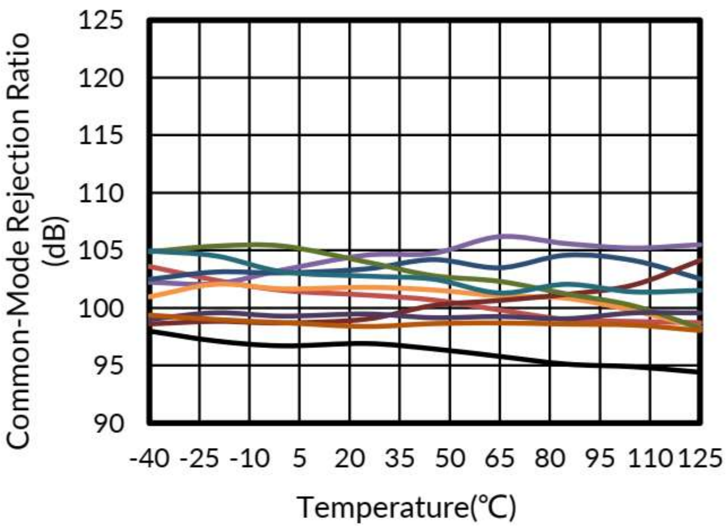


Figure 11. Common-Mode Rejection Ratio vs Temperature

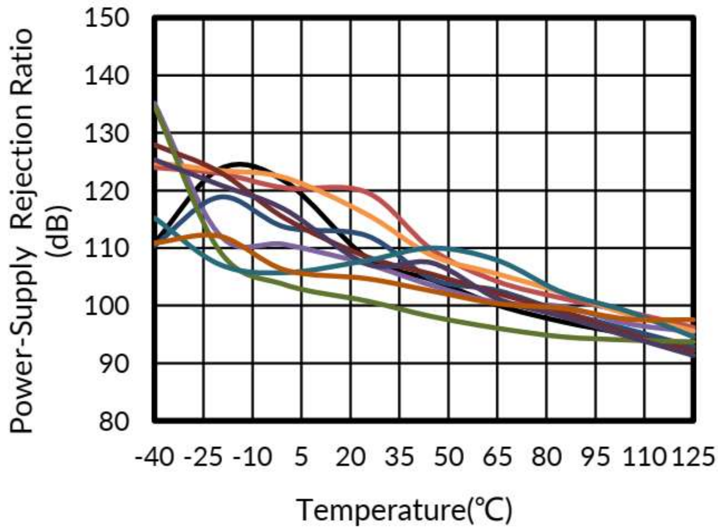


Figure 12. Power-Supply Rejection Ratio vs Temperature

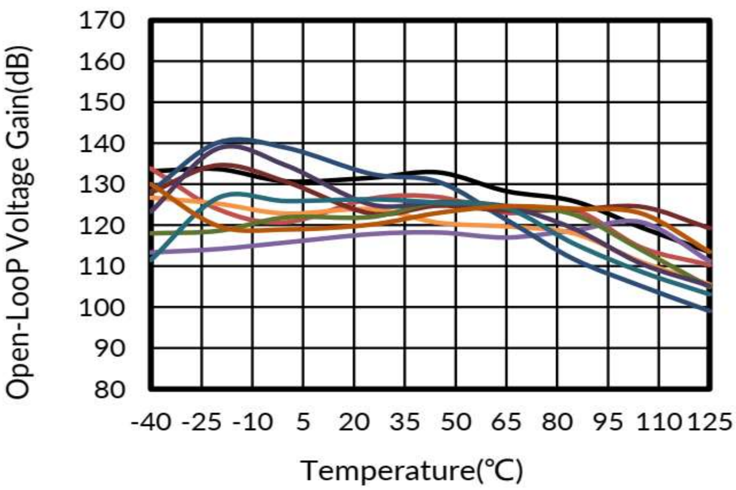


Figure 13. Open-Loop Voltage Gain vs Temperature

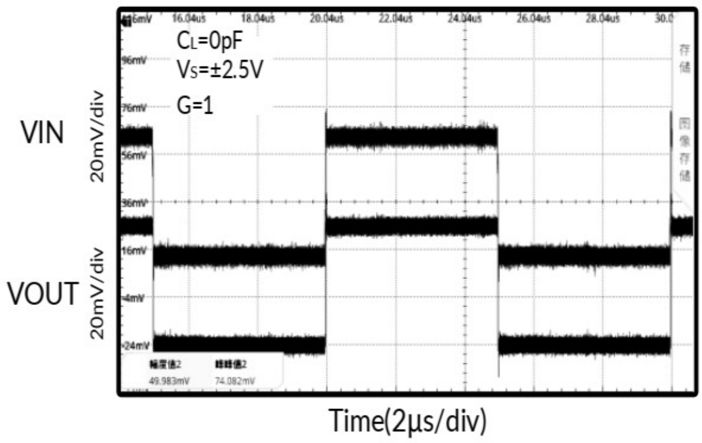


Figure 14. Small-Signal Step Response

Typical Performance Characteristics(con.)

(at TA=25'C, Vs=+5V, Unless Otherwise Noted.)

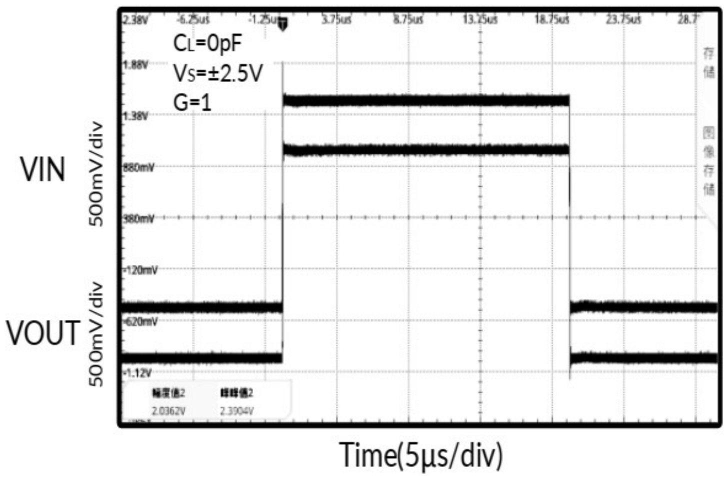
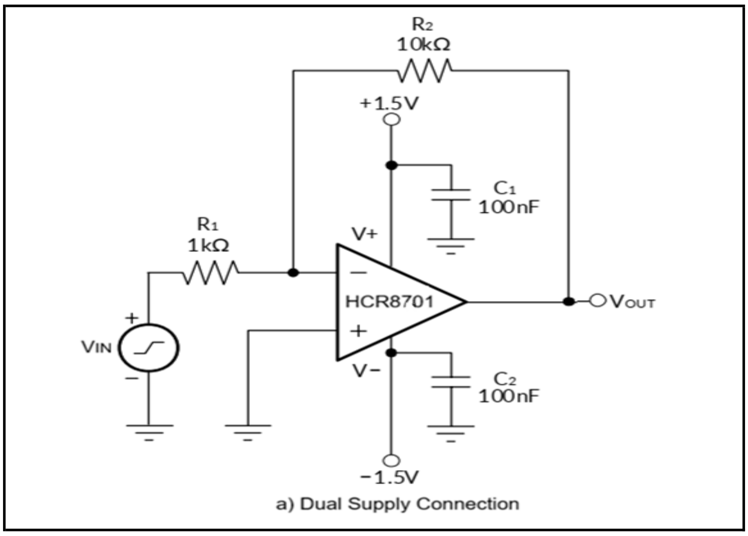


Figure 15. Large-Signal Step Response

Application Information

Basic Amplifier Configurations

As with other single-supply op amps, the HCR8701 /HCR8702 /HCR8704 may be operated with either a single supply or dual supplies. A typical dual-supply connection is shown in Figure 16, which is accompanied by a single-supply connection. The HCR8701/HCR8702 /HCR8704 is configured as a basic inverting amplifier with a gain of -10V/V. The dual-supply connection has an output voltage centered on zero, while the single-supply connection has an output centered on the common-mode voltage VCM. For the circuit shown, this voltage is 1.5 V, but may be any value within the common-mode input voltage range.



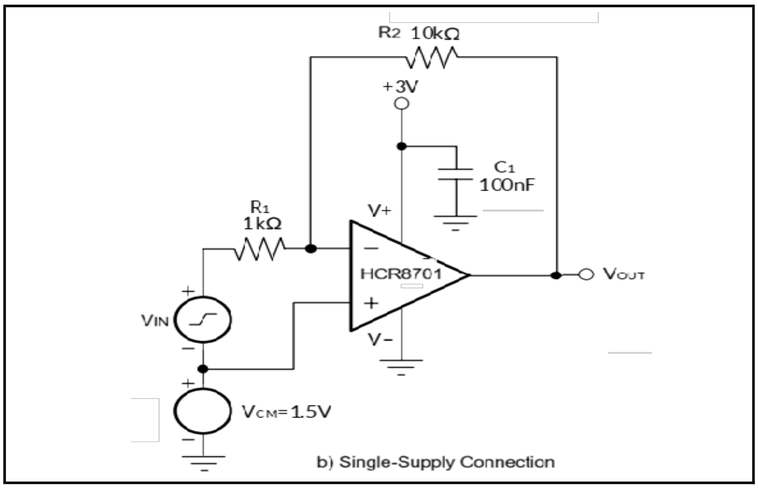


Figure 16. Basic Circuit Connections

Shows a single-supply, electret microphone application where VCM is provided by a resistive divider.The divider also provides the bias voltage for the electret element.

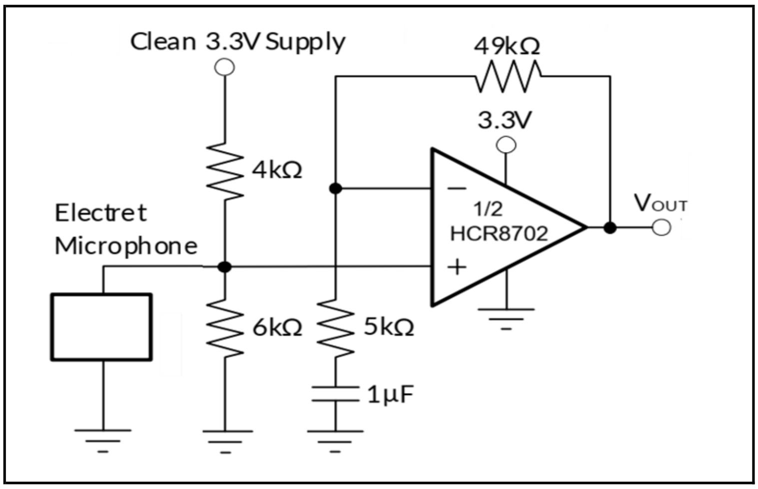


Figure 17. Microphone Preamplifier

Typical Application

Low-pass filters are commonly employed in signal processing applications to reduce noise and prevent aliasing, The HCR8701/HCR8702/HCR8704 is ideally suited to construct high-speed, high-precision active filters. Figure 18 illustrates a second-order low-pass filter commonly encountered in signal processing applications.

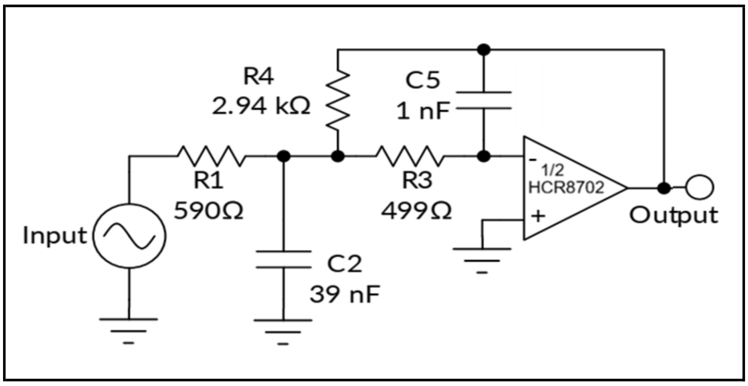


Figure 18. Second-Order Low-Pass Filter

Design Requirements

Use the following parameters for this design example:

- Gain = 5 V/V (inverting gain)
- Low-pass cutoff frequency = 25 kHz
- Second-order Chebyshev filter response with 3-dB gain peaking in the passband.

Detailed Design Procedure

The infinite-gain multiple-feedback circuit for a low-pass network function is shown in Figure 18. Use Equation 1 to calculate the voltage transfer function.

$$\frac{\text{Output}}{\text{Input}}(s) = \frac{-1/R_1R_3C_2C_5}{S^2+(S/C_2)(1/R_1+1/R_3+1/R_4)+1/R_3R_4C_2C_5} \quad (1)$$

This circuit produces a signal inversion. For this circuit the gain at DC and the low-pass frequency can be calculated by Equation 2:

$$\text{Gain} = \frac{R_4}{R_1}$$
$$f_C = \frac{1}{2\pi}\sqrt{(1/R_3R_4C_2C_5)} \quad (2)$$

Application Curve

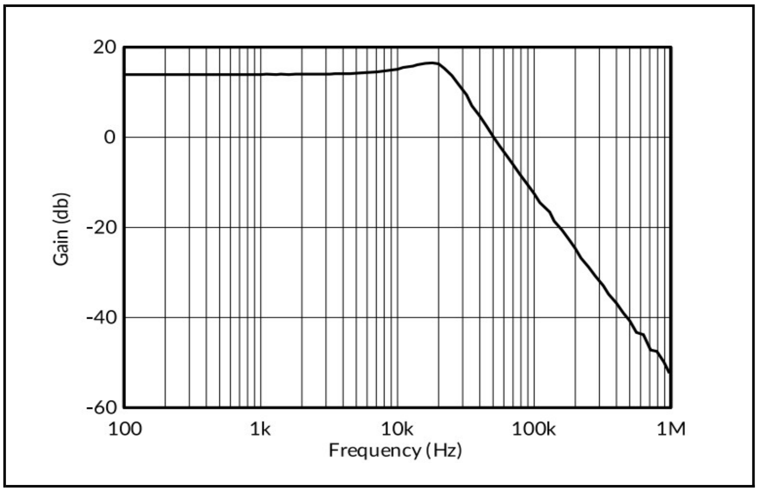


Figure 19. Second-Order 25 kHz, Chebyshev, Low-Pass Filter

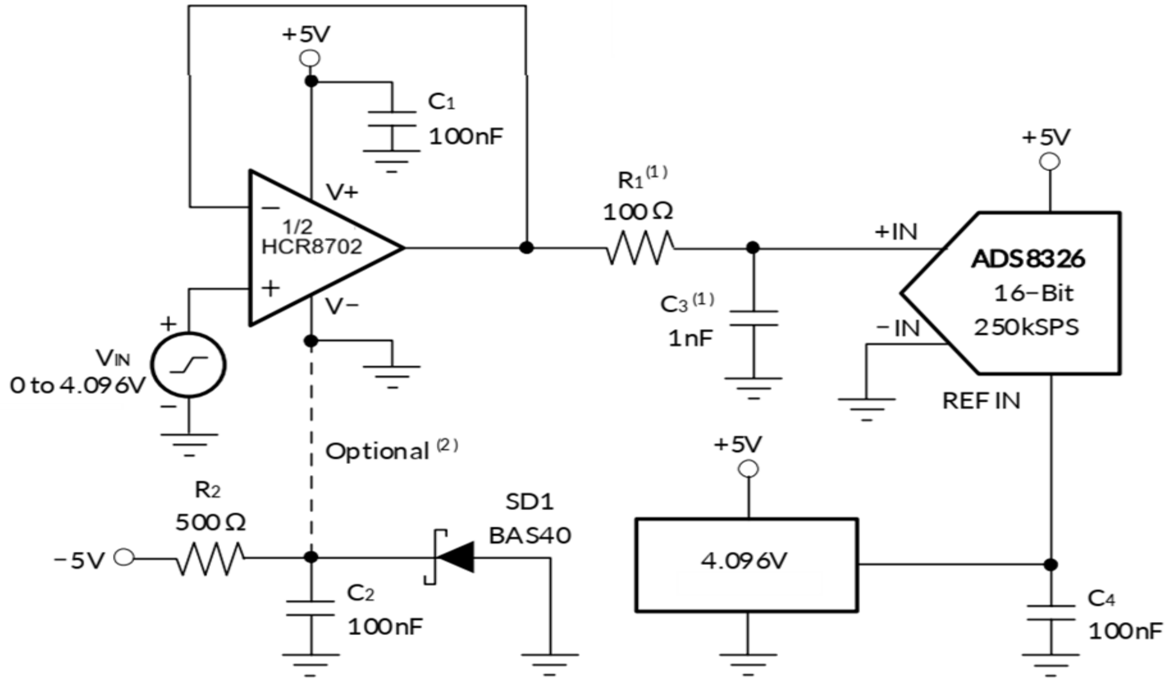
SYSTEM EXAMPLES

Driving an Analog-to-Digital Converter

Very wide common-mode input range, rail-to-rail input and output voltage capability, and high speed make the HCR8701 /HCR8702 /HCR8704 an ideal driver for modern ADCs. Also, because it is free of the input offset transition characteristics inherent to some rail-to-rail CMOS op amps, the HCR8701 /HCR8702 /HCR8704 provides low THD and excellent linearity throughout the input voltage swing range.

Figure 20 shows the HCR8701/HCR8702/HCR8704 driving an ADS8326, 16-bit, 250-kSPS converter. The amplifier is connected as a unity-gain, noninverting buffer and has an output swing to 0V, making it directly compatible with the ADC minus full-scale input level. The 0V level is achieved by powering the HCR8701 /HCR8702/HCR8704 V-pin with a small negative voltage established by the diode forward voltage drop. A small, signal-switching diode or Schottky diode provides a suitable negative supply voltage of -0.3 V to -0.7 V. The supply rail-to-rail is equal to V+, plus the small negative voltage.

SYSTEM EXAMPLES (con.)



Note (1) Suggested value; may require adjustment based on specific application.

(2) Single-supply applications lose a small number of ADC codes near ground due to op amp output swing limitation. If a negative power supply is available, this simple circuit creates a -0.3-V supply to allow output swing to true ground potential.

Figure 20. Driving the ADS8326

Layout Guidelines

For best operational performance of the device, use good PCB layout practices, including:

• Noise can propagate into analog circuitry through the power pins of the circuit as a whole and operational amplifier itself. Bypass capacitors are used to reduce the coupled noise by providing low-impedance power sources local to the analog circuitry.

1.1-Connect low-ESR, 0.1μF ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable for single supply applications.

1.2-The HCR8701/HCR8702/HCR8704 is capable of high-output current(in excess of 150 mA). Applications with low impedance loads or capacitive loads with fast transient signals demand large currents from the power supplies. Larger bypass capacitors such as 1μF solid tantalum capacitors may improve dynamic performance in these applications.

• Separate grounding for analog and digital portions of circuitry is one of the simplest and most-effective methods of noise suppression. One or more layers on multilayer PCBs are usually devoted to ground planes. A ground plane helps distribute heat and reduces EMI noise pickup. Make sure to physically separate digital and analog grounds paying attention to the flow of the ground current.

• To reduce parasitic coupling, run the input traces as far away from the supply or output traces as possible. If these traces cannot be kept separate, crossing the sensitive trace perpendicular is much better as opposed to in parallel with the noisy trace.

• Place the external components as close to the device as possible. As shown in Figure 21, keeping RF and RG close to the inverting input minimizes parasitic capacitance.

Layout Guidelines(con.)

- Keep the length of input traces as short as possible. Always remember that the input traces are the most sensitive part of the circuit.
- Consider a driven, low-impedance guard ring around the critical traces. A guard ring can significantly reduce leakage currents from nearby traces that are at different potentials.
- Cleaning the PCB following board assembly is recommended for best performance.
- Any precision integrated circuit may experience performance shifts due to moisture ingress into the plastic package. Following any aqueous PCB cleaning process, baking the PCB assembly is recommended to remove moisture introduced into the device packaging during the cleaning process. A low temperature, post cleaning bake at 85°C for 30 minutes is sufficient for most circumstances

Layout Example

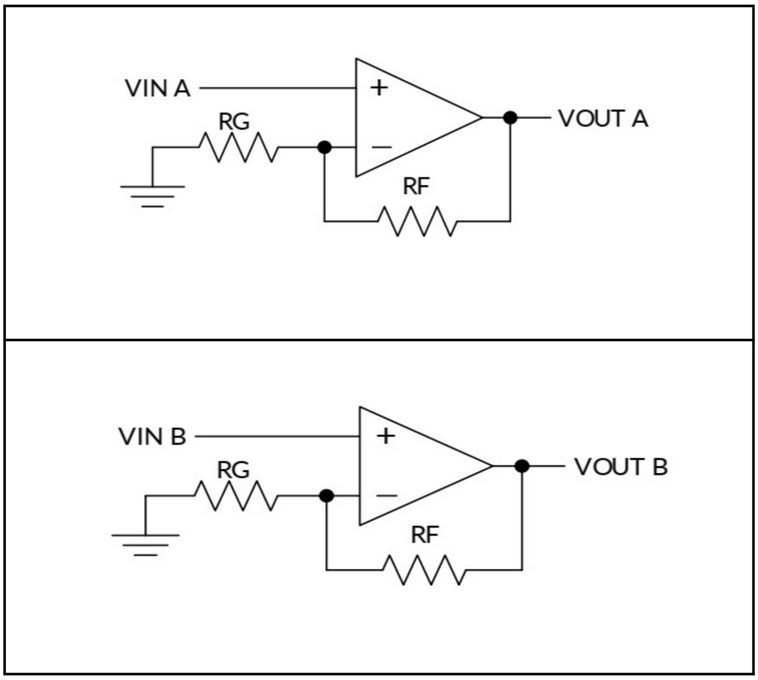
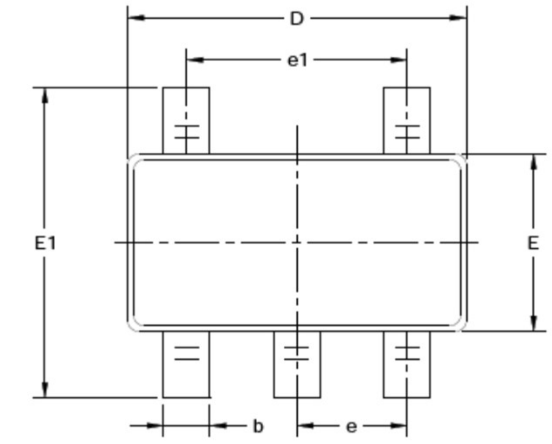
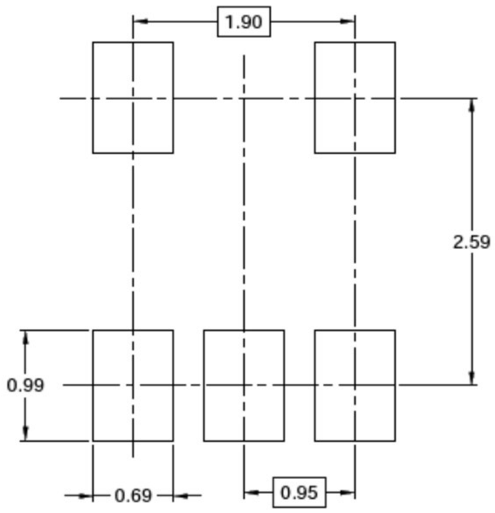


Figure 21. Schematic Representation

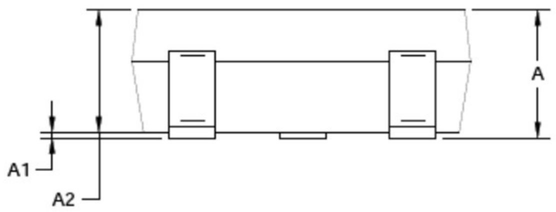
Mechanical Dimensions

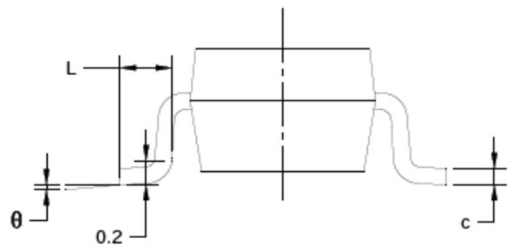
M5: SOT23-5 package





RECOMMENDED LAND PATTERN (Unit: mm)



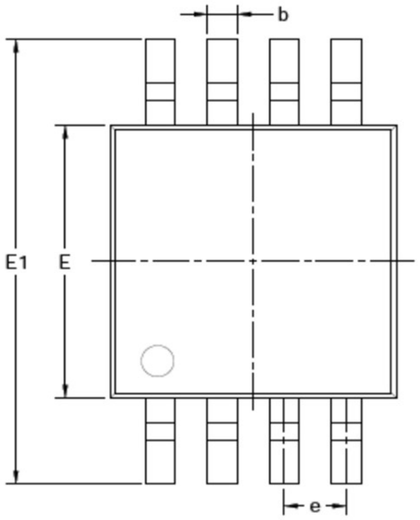


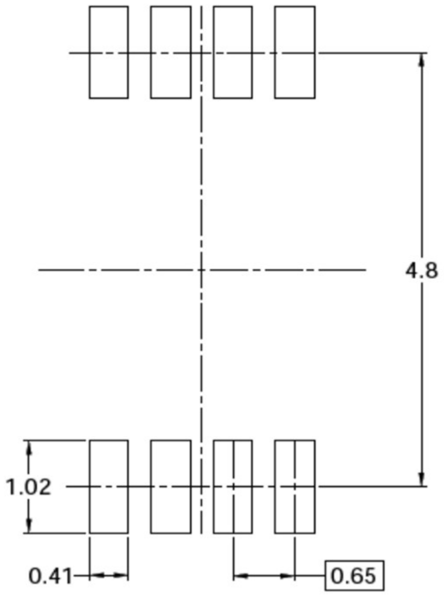
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

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

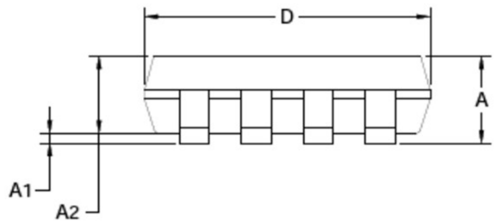
Mechanical Dimensions(Con.)

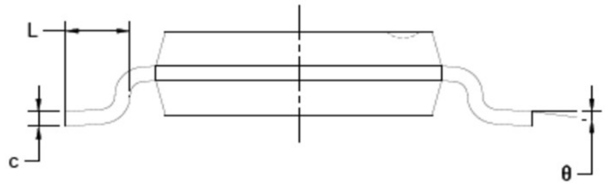
SM8: MSOP-8 Package





RECOMMENDED LAND PATTERN (Unit: mm)



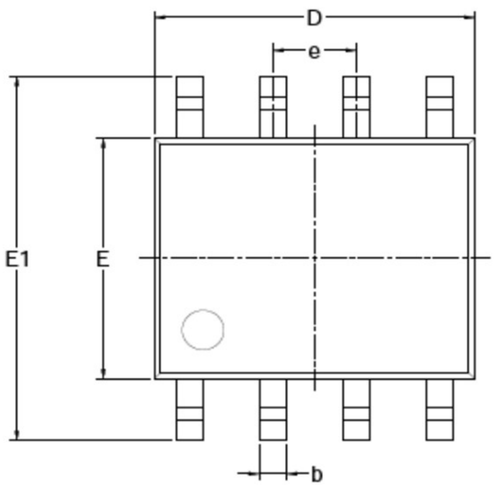


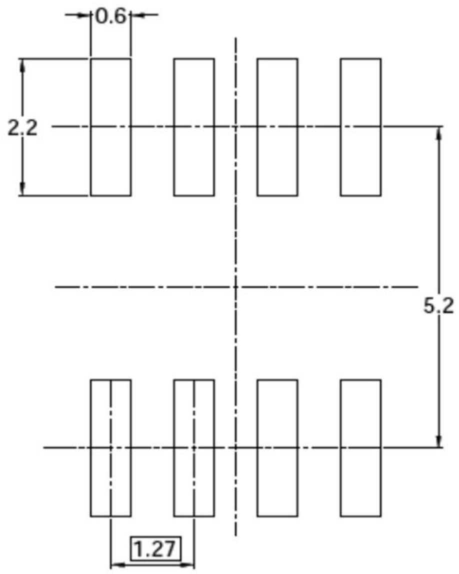
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026 BSC	
L	0.400	0.800	0.016	0.031
θ	0°	6°	0°	6°

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

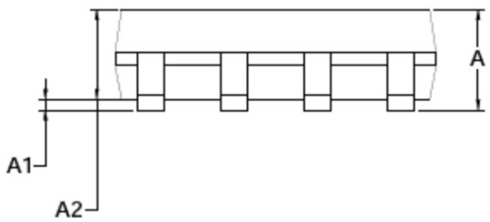
Mechanical Dimensions(Con.)

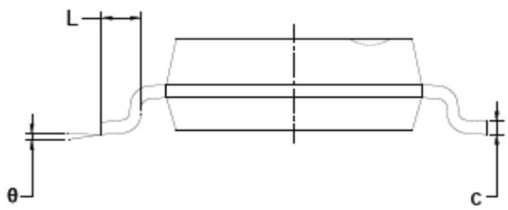
M8: SOIC-8(SOP-8) Package





RECOMMENDED LAND PATTERN (Unit: mm)



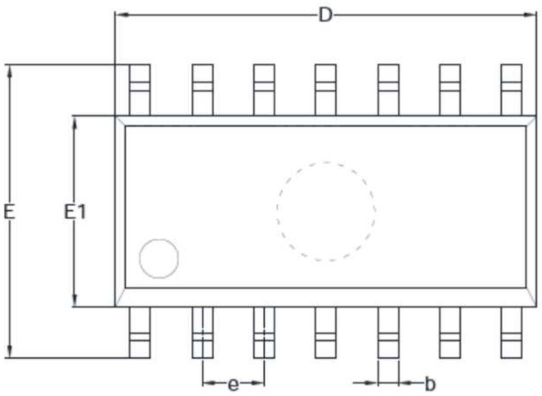


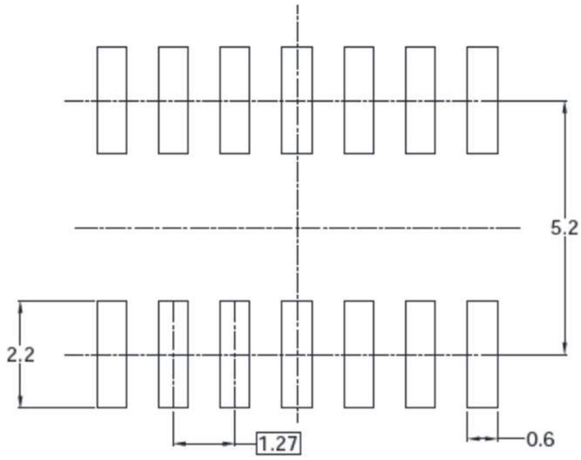
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

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

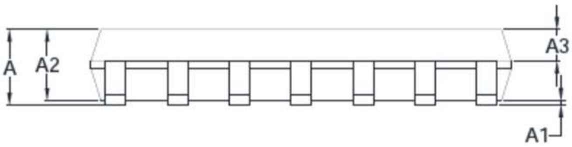
Mechanical Dimensions(Con.)

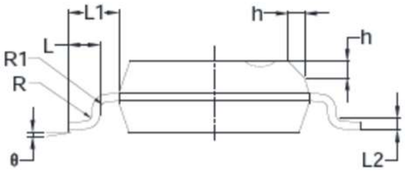
M14: SOIC-14 Package





RECOMMENDED LAND PATTERN (Unit: mm)



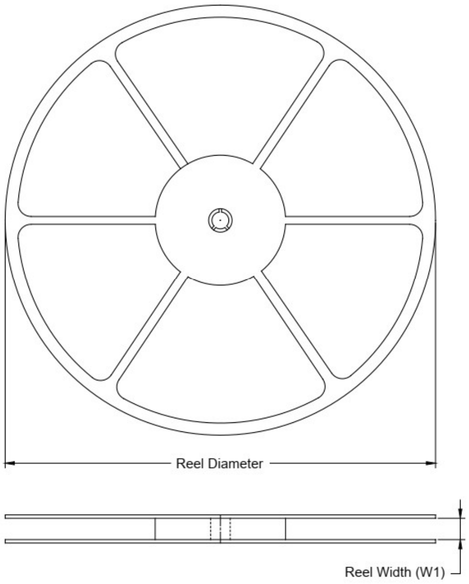


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.55	0.75	0.022	0.030
b	0.36	0.49	0.014	0.019
D	8.53	8.73	0.336	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
L	0.45	0.80	0.018	0.032
L1	1.04 REF		0.040 REF	
L2	0.25 BSC		0.01 BSC	
R	0.07		0.003	
R1	0.07		0.003	
h	0.30	0.50	0.012	0.020
θ	0°	8°	0°	8°

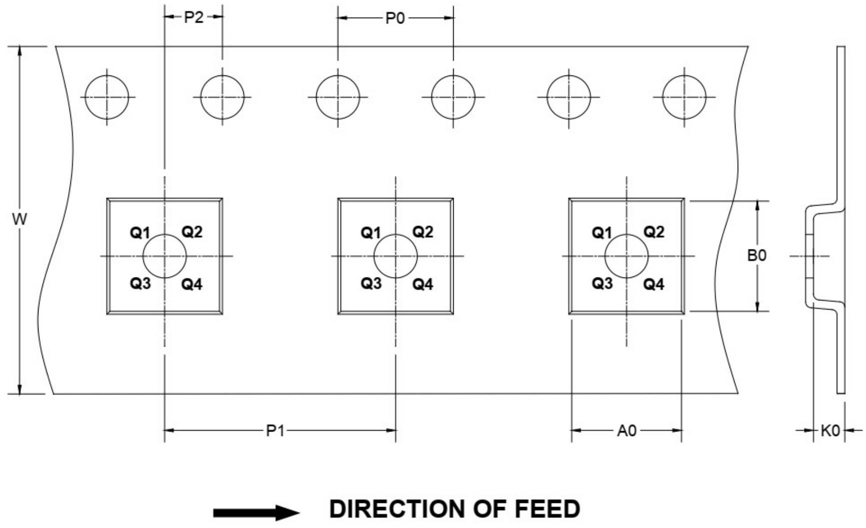
NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS

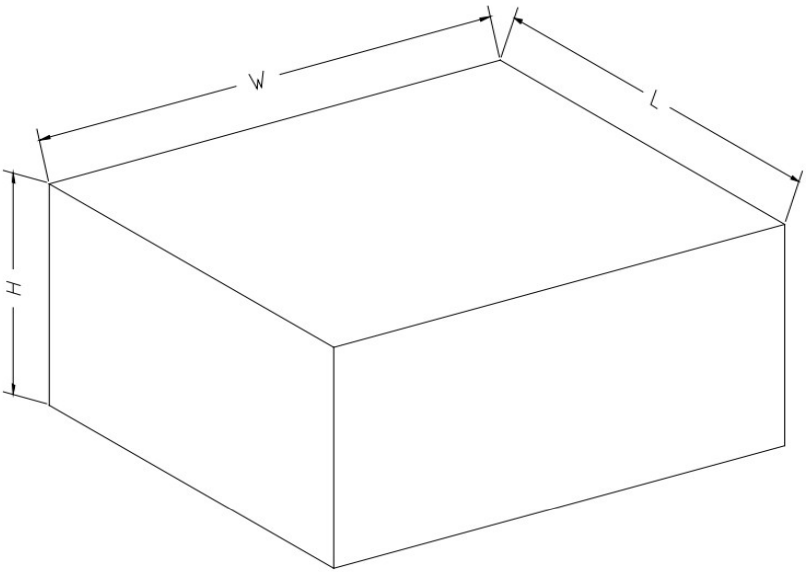


NOTE: The picture is only for reference. Please make the object as the standard.

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
SOT-23-5	7"	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3
SOIC-8	13"	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	Q1
MSOP-8	13"	12.4	5.20	3.30	1.50	4.0	8.0	2.0	12.0	Q1
SOIC-14	13"	16.4	6.60	9.30	2.10	4.0	8.0	2.0	16.0	Q1

CARTON BOX DIMENSIONS



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

KEY PARAMETER LIST OF CARTON BOX

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