250MHz, Rail-to-Rail Input/Output CMOS Operational Amplifier

Features

* Unity-Gain Bandwidth: 250MHz
* Gain Bandwidth: 120MHz
* High Slew Rate: 180V/μ s
* Offset Voltage: 1mV typical
* Low Noise: 6nV/ √ Hz
* Rail-to-Rail Input and Output
* Input Voltage Range: -0.1V to Vs+0.1V with Vs=5V
* High Output Current: >100mA
* Supply Voltage Range: +2.7V to +5.5V
* Operating Temperature: -40'C to +125‘C
* Available in Green Package:
  - HCR8761 in SOT23-5 packages
  - HCR8762 in MSOP8, TSSOP8 and SOIC-8(SOP-8) Packages
  - HCR8764 in TSSOP14 and SOIC-14(SOP-14) Packages

General Description note a

The HCR8761/HCR8762/HCR8764 families of voltage-feedback (VFB) products offer low voltage operation, rail to rail input and output, as well as excellent speed/power consumption ratio, providing an excellent bandwidth (250MHz) and slew rate of 180V/μs. The op-amps are unity gain stable and feature an ultra-low input bias current。

These amplifiers set an industry-leading power-to-perfor mance ratio for rail-to-rail amplifiers. The HCR8761 /HCR8762/HCR8764 families of operational amplifiers are specified at the full temperature range of -40°C to +125°C under single or dual power supplies of 2.7V to 5.5V。

Applications

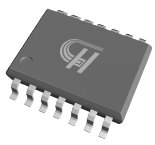
* Audio ADC Input Buffers
* Photodiode Preamp
* High-Density Systems
* Portable Systems
* Driving A/D Converters
* Video Processing


SOT23-5


MSOP8


TSSOP-8


SOIC-8(SOP-8)


TSSOP-14

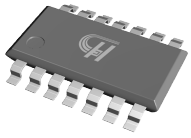
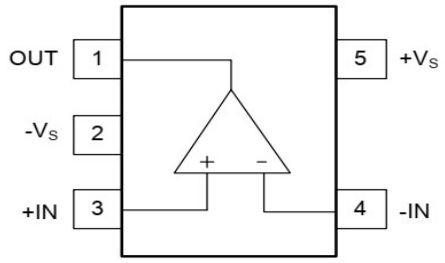

SOIC-14(SOP-14)

Figure 1. Package Type of HCR8761/HCR8762/HCR8764

250MHz, Rail-to-Rail Input/Output CMOS Operational Amplifier

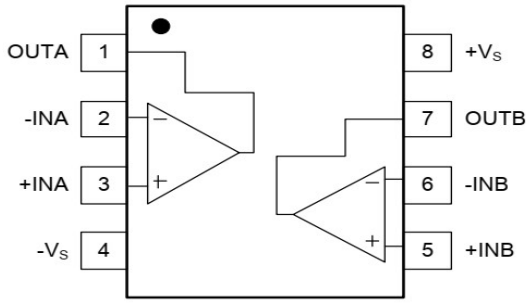
Pin Configuration

HCR8761(TOP VIEW)



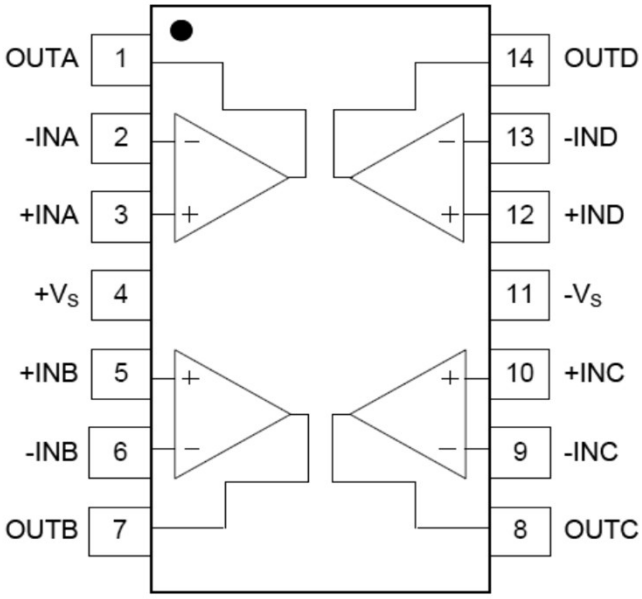
SOT23-5

HCR8762(TOP VIEW)



SOIC-8(SOP-8)/MSOP8 /TSSOP-8

HCR8764 (TOP VIEW)



SOIC-14(SOP-14)/TSSOP-14

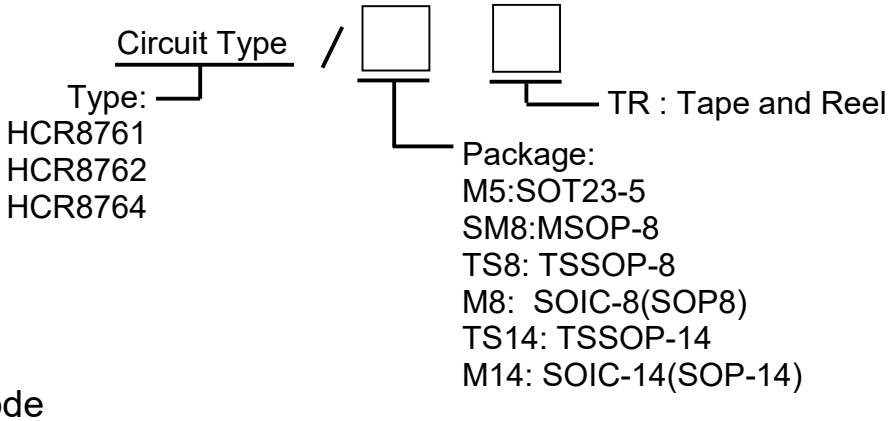
Figure 2. Pin Configuration of HCR8761/HCR8762/HCR8764(Top View)

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

250MHz, Rail-to-Rail Input/Output CMOS Operational Amplifier

Ordering Information



Ordering Code

Part Number	Channel	Marking (1)	Op Temp('C)	MSL(2)	Package	Package Qty
HCR8761/M5TR	1	8761XX	-40'C to +125'C	MSL3	SOT23-5	3000pcs/TR
HCR8762/SM8TR	2	HCR8762Sxx	-40'C to +125'C	MSL3	MSOP-8	4000pcs/TR
HCR8762/TS8TR	2	HCR8762Txx	-40'C to +125'C	MSL3	TSSOP-8	4000pcs/TR
HCR8762/M8TR	2	HCR8762Mxx	-40'C to +125'C	MSL3	SOIC-8 (SOP-8)	4000pcs/TR
HCR8704/TS14TR	4	HCR8764Txx	-40'C to +125'C	MSL3	TSSOP-14	4000pcs/TR
HCR8704/M14TR	4	HCR8764Mxx	-40'C to +125'C	MSL3	SOIC-14 (SOP-14)	4000pcs/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.

250MHz, Rail-to-Rail Input/Output CMOS Operational Amplifier

Absolute Maximum Ratings

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

Parameter		Symbol	Min.	Max.	Unit
Supply Voltage, +Vs to -Vs		V+	-	+7.0	V
Signal Input Voltage		VIN	(V-) -0.3	(V+) +0.3	V
Signal Output Voltage		Vout	(V-) -0.2	(V+) +0.2	V
Signal Input Current		IIN	-10	+10	mA
Signal Output Current		Iout	-50	+50	mA
Output Short-circuit (3)		-	Continuous		
Thermal Resistance (4) @TA=+25'C	SOT23-5	θJA	-	230	'C/W
	MSOP-8	θJA	-	170	'C/W
	TSSOP-8	θJA	-	240	'C/W
	SOIC-8	θJA	-	110	'C/W
	TSSOP-14	θJA	-	105	'C/W
	SOIC-14	θJA	-	90	'C/W
Storage Temperature Range		TSTG	-65	+150	'C
Operating Temperature Range note 2		TOPR	-40	+125	'C
Junction Temperature (5)		TJ	-40	+150	'C
Lead Temperature (Soldering, 10s)		TLEAD	260		'C
Human Body Model ESD Protection		ESD HBM	5		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	2.7	5.5	V
	Dual-supply		±1.35	±2.75	V
Operating Temperature Range		Ta	-40	+125	'C

250MHz, Rail-to-Rail Input/Output CMOS Operational Amplifier

Electrical Characteristics

(TA=25 `C, Vs=2.7V to +5.5V, RL=0Ω, VOUT=0V. Full= -40'C to 125'C, Unless Otherwise Specified.)[1]

Parameter	Symbol	Conditions	TEMP	Min.[2]	Typ.[3]	Max.[2]	Unit
Input Characteristics							
Input Offset Voltage	VOS	Vs=5V, VCM =Vs /2	25'C	-2	±1	2	mV
			Full	-3	-	3	
Input Offset Voltage Drift	ΔVOS Tc		Full	-	±10	-	uV/'C
Input Bias Current[4][5]	IB	Vs=5V	25'C	-	±3	-	pA
			Full	-	±300	-	pA
Input Offset Current[4]	IOS	Vs=5V	25'C	-	3	-	pA
Input Capacitance	CIN	Differential Mode	25'C	-	3.5	-	pF
		Common Mode	25'C	-	2.5	-	
Common-Mode Voltage Range	VCM		Full	(V-)-0.1	-	(V+) +0.1	V
Common Mode Rejection Ratio	CMRR	Vs=5V, VCM=0 to 3V	25'C	60	80	-	dB
			Full	55	-	-	
		Vs=5V, VCM=0 to 5V	25'C	60	75	-	
			Full	55	-	-	
Open-Loop Voltage Gain	AOL	RLOAD=2KΩ, Vout= -2.4V to 2.4V	25'C	95	105	-	dB
		RLOAD=2KΩ, Vout= -2.35V to 2.35V	Full	80	-	-	
Output Characteristics							
Output Swing from Positive Rail	VOH	RLOAD=100KΩ to Vs/2	25'C	-	7	20	mV
Output Swing from Negative Rail	VOL	RLOAD=100KΩ to Vs/2	25'C	-	4	20	
Output Source Current	ISOURCE	VS=5V[5][6]	25'C	-	200	-	mA
Output Sink Current	ISINK		25'C	-	250	-	
Closed-Loop Output Impedance[4]	Rout	G=1, f=1KHz, Iout=0	25'C	-	0.01	-	Ω
Open-Loop Output Impedance[4]	Ro	f=1KHz, Iout=0	25'C	-	21	-	
Power Supply							
Operating Voltage Range	Vs		Full	2.7	-	5.5	V
Quiescent Current per Amplifier	IQ	Vs=2.7V	25'C	-	6.3	8.5	mA
			Full	-	-	11	
		Vs=5V	25'C	-	8.3	10	
			Full	-	-	13	
Power Supply Rejection Ratio	PSRR	Vs=2.7V to 5.5V	25'C	65	80	-	dB
			Full	55	-	-	

Electrical Characteristics(Con.)

(TA=25 `C, Vs=2.7V to +5.5V, RL=0Ω, VOUT=0V. Full= -40'C to 125'C, Unless Otherwise Specified.)

Parameter	Symbol	Conditions	TEMP	Min	Type	Max	Unit
Dynamic Performance							
Small-Signal Bandwidth[4]	f-3dB	G= +1, Vo=100mVpp	25'C	-	250	-	MHz
		G= +2, Vo=100mVpp	25'C	-	90	-	
Gain-Bandwidth Product	GBW	G= +10	25'C	-	120	-	MHz
Slew Rate[8]	SR	Vs= +5V, G=1, 4V Step	25'C	-	200	-	V/uS
		Vs= +5V, G=1, 2V Step	25'C	-	180	-	
		Vs= +3V, G=1, 2V Step	25'C	-	140	-	
Rise-and-Fall Time	tf	G= +1, Vo=200mVpp, 10% to 90%	25'C	-	7	-	nS
		G= +1, Vo=2Vpp, 10% to 90%	25'C	-	2.5	-	nS
Settling Time to 0.1%[4]	ts	G= 1, 2V Step	25'C	-	25	-	nS
Overload Recovery Time	tOR	VINxGain=Vs	25'C	-	40	-	nS
Phase Margin	PM	G=1	25'C	-	60	-	deg
Noise Performance							
Input Voltage Noise	En	Vs=5V, f=0.1Hz to 10Hz	25'C	-	51	-	uVpp
Input Voltage Noise Density[4]	en	f=1MHz	25'C	-	6	-	nV/ √ Hz

Note: (1) Electrical table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device.

(2) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.

(3) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration.

(4) This parameter is ensured by design and/or characterization and is not tested in production.

(5) Positive current corresponds to current flowing into the device.

(6) 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.

(7) Short circuit test is a momentary test.

(8) Number specified is the slower of positive and negative slew rates.

(9) Specified by characterization only.

Typical Performance Characteristics.

(Ta=25'C, VS = 5V, G = +1, RF = 0Ω, RL = 1kΩ, and connected to VS/2, unless otherwise specified)

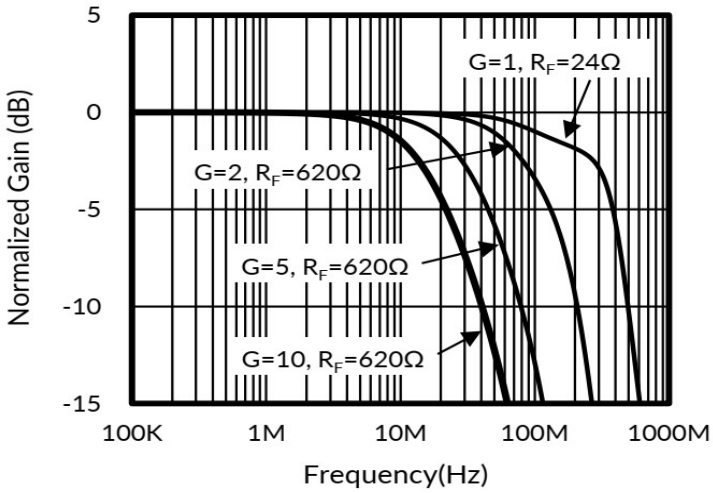


Figure 3. Noninverting Small Signal Frequency Response

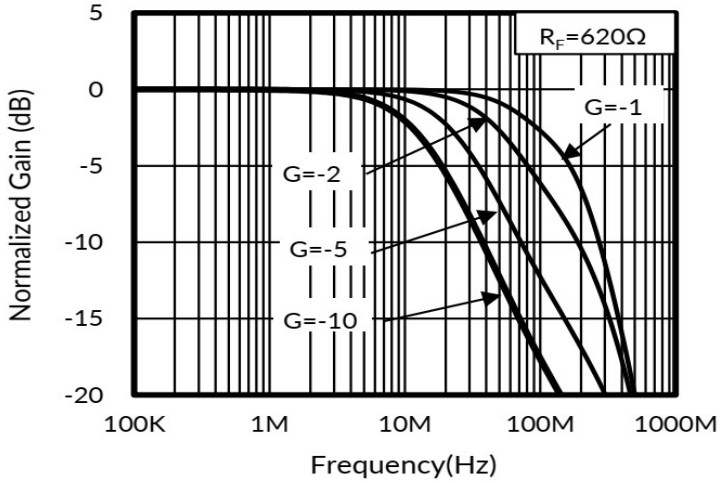


Figure 4. Inverting Small Signal Frequency Response

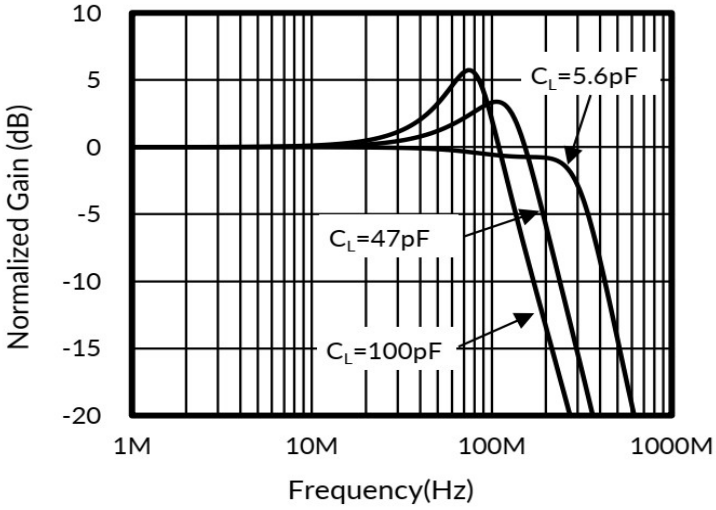


Figure 5. Frequency Response for Various CL

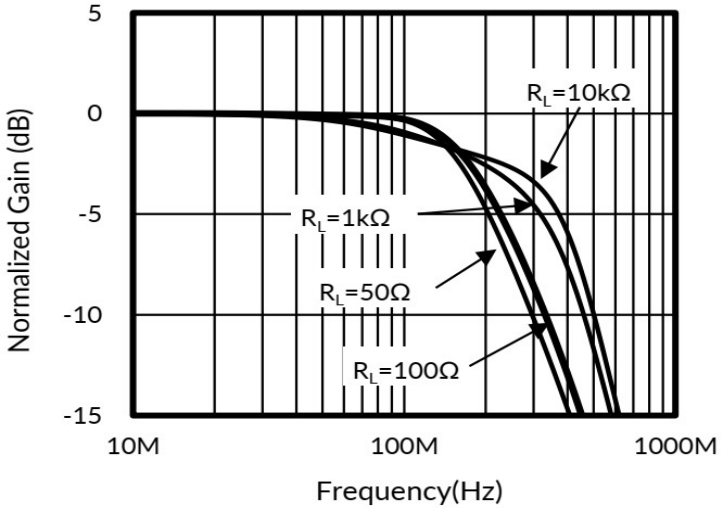


Figure 6. Frequency Response for Various RL

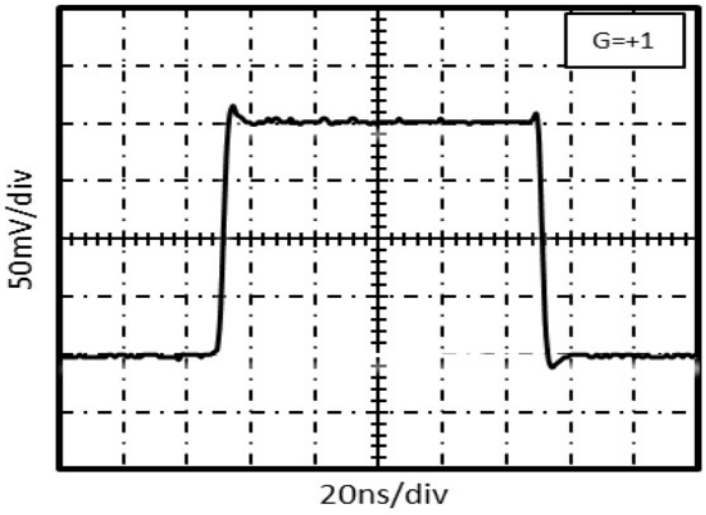


Figure 7. Small Signal Step Response

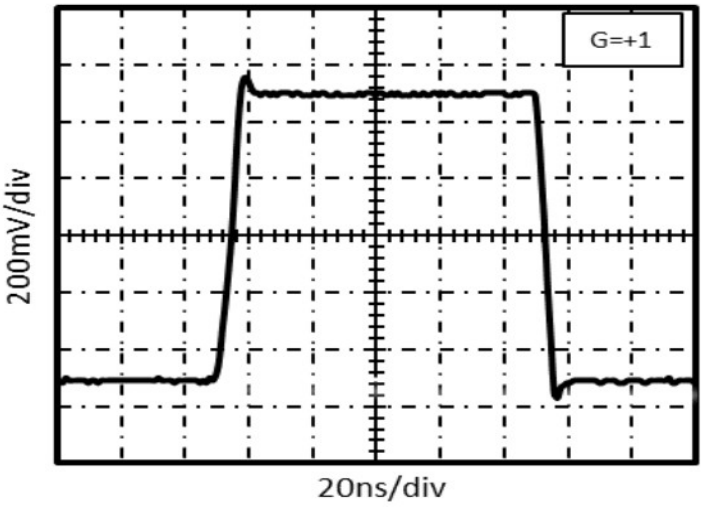


Figure 8. Large Signal Step Response

Typical Performance Characteristics(con.)

(Ta=25'C, VS = 5V, G = +1, RF = 0Ω, RL = 1kΩ, and connected to VS/2, unless otherwise specified)

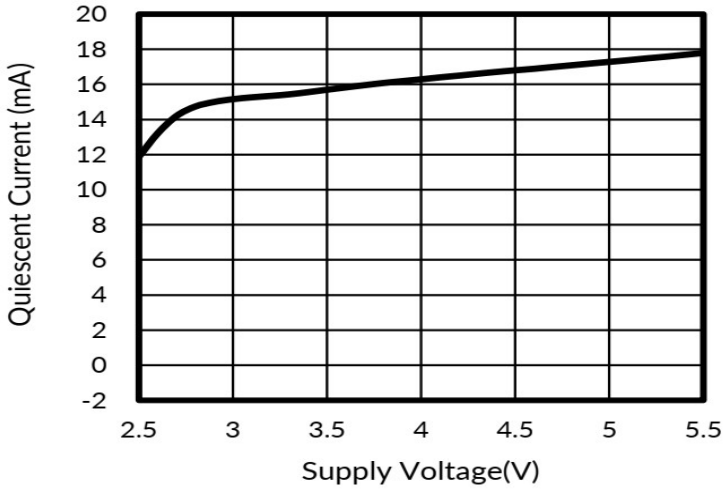


Figure 9. Quiescent Current vs Supply Voltage

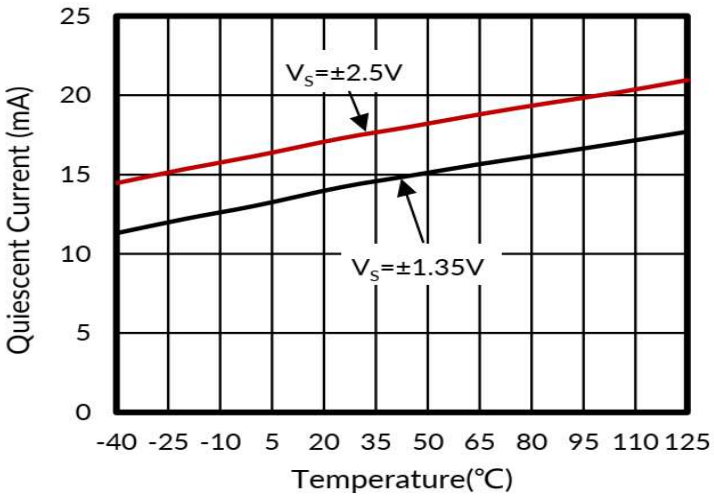


Figure 10. Quiescent Current vs Temperature

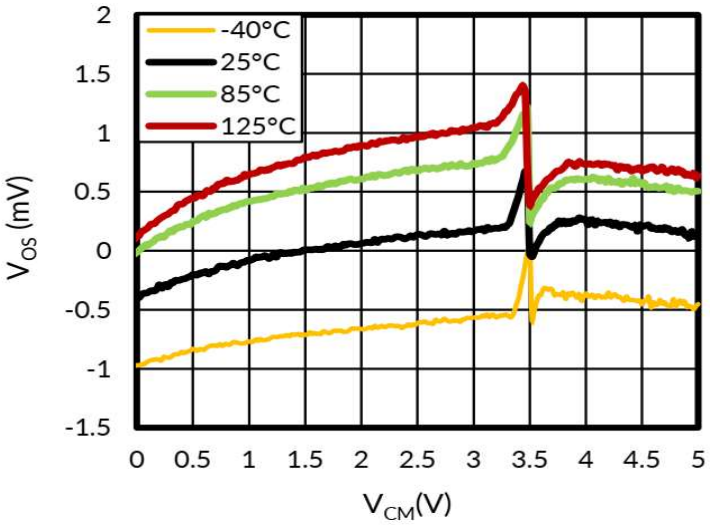


Figure 11. Input Offset Voltage vs Common Mode Voltage

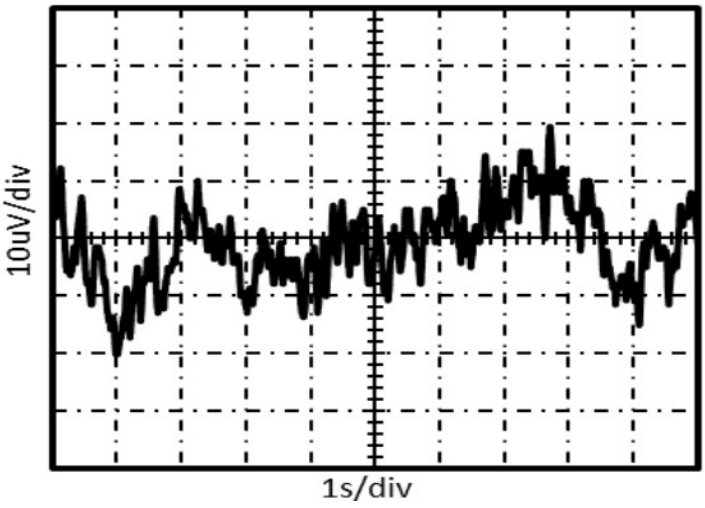


Figure 12. 0.1Hz to 10Hz Noise

DETAILED DESCRIPTION

Overview

The HCR8761/HCR8762/HCR8764 devices are unity-gain stable, dual and qual-channel op amps with low noise and distortion. The device consists of a low noise input stage with a folded cascade and a rail-to-rail output stage. This topology exhibits superior noise and distortion performance across a wide range of supply voltages that are not delivered by legacy commodity audio operational amplifiers.

Power On Requirement

For the high-speed amplifier, in order to avoid the band -width limit of the input transistors parasitic capacitance, it is generally not large enough, so the offset voltage is larger than the general amplifier. The HCR8761/ HCR8762/HCR8764 uses internal calibration circuits to calibrate the offset voltage under high and low common mode conditions,so the typical value of the offset voltage can be 1 mV. The performance is better than most high -speed amplifiers. To ensure the normal calibration function. When using the amplifier, users should pay attention to the high and low VCM switching points, generally near VDD-1.5V. To guarantee the calibration block works properly, good power on of the amplifier power supply is recommended:

- Fast power on time to produce the power on reset signal of calibration block. The maximum value of power on time is 1ms.
- Avoid the voltage glitch reaching in 0.4V to 1V range on power supply. For example, power supply drop to 0.5V then recovery to 5V may cause error of calibration block.

If the power on signal is not good, the amplifier has probability to enter an unexpected status.

Phase Reversal Protection

The HCR8761/HCR8762/HCR8764 family has internal phase-reversal protection. Many op amps exhibit phase reversal when the input is driven beyond the linear common-mode range. This condition is most often

Phase Reversal Protection(con.)

encountered in noninverting circuits when the input is driven beyond the specified common-mode voltage range, causing the output to reverse into the opposite rail. The input of the HCR8761/HCR8762/HCR8764 prevents phase reversal with excessive common-mode voltage. Instead, the appropriate rail limits the output voltage. This performance is shown in figure 13.

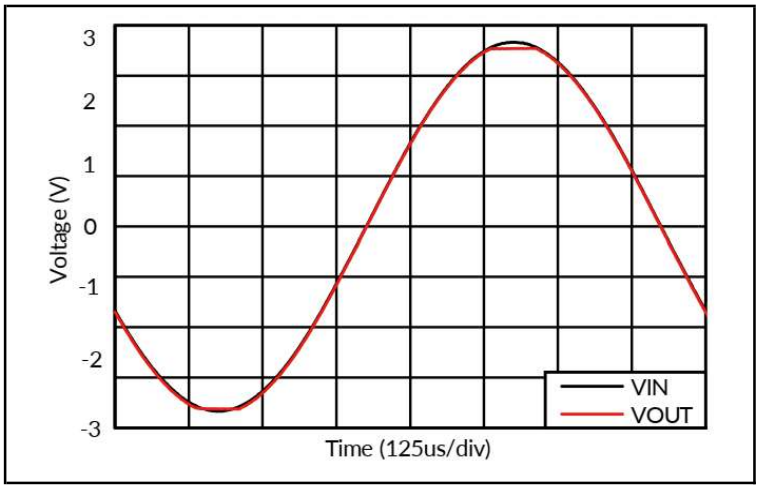


Figure 13. Output Waveform Devoid of Phase Reversal during an Input Overdrive Condition

Gain Bandwidth Product

For applications that require a gain of +1, no feedback resistor is required. Just short the output pin to the inverting input pin. For gains greater than +1, the feedback resistor forms a pole with the parasitic capacitance at the inverting input. As this pole becomes smaller, the amplifier's phase margin is reduced. This causes ringing in the time domain and peaking in the frequency domain. Therefore, RF has some maximum value that should not be exceeded for optimum performance. If a large value of RF must be used, a small capacitor in the few Picofarad range in parallel with RF can help to reduce the ringing and peaking at the expense of reducing the bandwidth. As far as the output stage of the amplifier is concerned, the output stage is also a gain stage with the load. RF and RG appear in parallel with RL for gains other than +1. As this combination gets smaller, the bandwidth falls off. Consequently, RF also has a minimum value that should

DETAILED DESCRIPTION(con.)

Gain Bandwidth Product(con.)

not be exceeded for optimum performance. For gain of +1, RF=0 is optimum. For the gains other than +1, optimum response is obtained with RF between 300Ω to 1kΩ, The HCR8761/HCR8762/HCR8764 have again bandwidth product of 120MHz. For gains >=5, its band -width can be predicted by the following equation:

Gain × BW=120MHz

Capacitive Load Driving Capability

The HCR8761/HCR8762/HCR8764 has large output current driving ability and good stability. When the drive output load resistance is 1kΩ and the output capacitor is 40pF, the frequency response curve peak is less than 5dB. If less peaking is desired in applications, a small series resistor (usually 50Ω) can be placed in series with the output to eliminate most peaking. However, this will reduce the gain slightly. If the gain setting is greater than 1, the gain resistor RG can then be chosen to make up for any gain loss which may be created by the additional series resistor at the output. When used as a cable driver,double termination is always recommended for reflection-free performance.

For those applications, a back-termination series resistor at the amplifier's output will isolate the amplifier from the cable and allow extensive capacitive drive. However, other applications may have high capacitive loads without a back-termination resistor. Again, a small series resistor at the output can help to reduce peaking.

Video Performance

For good video performance, an amplifier is required to maintain the same output impedance and the same frequency response as DC levels are changed at the output. This is especially difficult when driving a standard video load of 150Ω, because the change in output current with DC level. Special circuitry has been incorporated in the HCR8761/HCR8762/HCR8764 to reduce the variation of the output impedance with the current output. This results in Dg and Dp specifications

Video Performance(con.)

of 0.03% and 0.3°, while driving 150Ω at a gain of 2. Driving high impedance loads would give a similar or better Dg and Dp performance.

Output Drive Capability

The HCR8761/HCR8762/HCR8764 output stage can supply a continuous output current of ±100mA and still provide approximately 2.7V of output swing on a 5V supply.For maximum reliability, it is not recommended to run a continuous DC current in excess of ±100mA. Refer to the typical characteristic curve Output Voltage Swing vs Output Current. For supplying continuous output currents greater than ±100mA, the HCR8761/ HCR8762/HCR8764 may be operated in parallel.

The HCR8761/HCR8762/HCR8764 will provide peak currents up to 200mA, which corresponds to the typical short-circuit current.

Input ESD Diode Protection

The HCR8761, HCR8762 and HCR8764 uses internal electrostatic discharge (ESD) protection circuits on all pins. In the case of input and output pins, this protection primarily consists of current-steering diodes connected between the input and power-supply pins. The following figure shows the schematic diagram of the ESD structure.

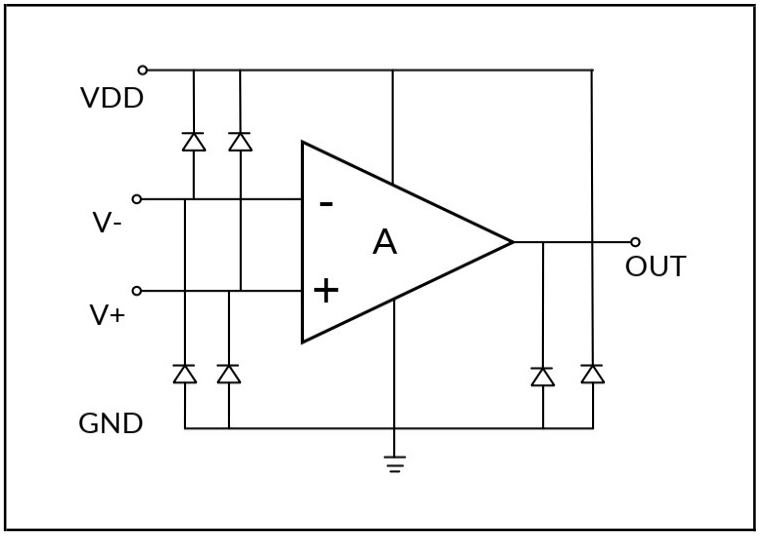


Figure 14. Input ESD Diode

DETAILED DESCRIPTION(con.)

Power Supply Bypassing and Printed Circuit Board Layout

As with any high frequency device, a good printed circuit board layout is necessary for optimum performance. Lead lengths should be as sort as possible. The power supply pin must be well bypassed to reduce the risk of oscillation. For normal single supply operation, where the V- pin is connected to the ground plane, a single 4.7mF tantalum capacitor in parallel with a 0.1mF ceramic capacitor from V+ to GND will suffice. This same capacitor combination should be placed at each supply pin to ground if split supplies are to be used. In this case, the V- pin becomes the negative supply rail. For good AC performance, parasitic capacitance should be kept to a minimum. Use of wire wound resistors should be avoided because of their additional series inductance. Use of sockets should also be avoided if possible. Sockets add parasitic inductance and capacitance that can result in compromised performance. Minimizing parasitic capacitance at the amplifier's inverting input pin is very important. The feedback resistor should be placed very close to the inverting input pin. Strip line design techniques are recommended for the signal traces.

Application Note

The HCR8761/HCR8762/HCR8764 are high precision, rail-to-rail operational amplifiers that can be run from a single-supply voltage 2.7V to 5.5V (±1.35V to ±2.75V). Supply voltages higher than 7V(absolute maximum) can permanently damage the amplifier. Rail-to-rail output swing significantly increases dynamic range, especially in low-supply applications. Good layout practice mandates use of a 0.1μF capacitor place closely across the supply pins.

Single Supply Video Line Driver

The HCR8761 /HCR8762 /HCR8764 are wide band rail-to-rail output op amplifiers with large output current, excellent Dg, Dp, and low distortion that allow them to drive video signals in low supply applications. Figure below is the single supply non-inverting video line driver configuration and inverting video ling driver configuration. The signal is AC coupled by C1. R1 and R2 are used to level shift the input and output to provide the largest output swing. RF and RG set the AC gain. C2 isolates the virtual ground potential. RT and R3 are the termination resistors for the line. C1, C2 and C3 are selected big enough to minimize the drop of the luminance signal.

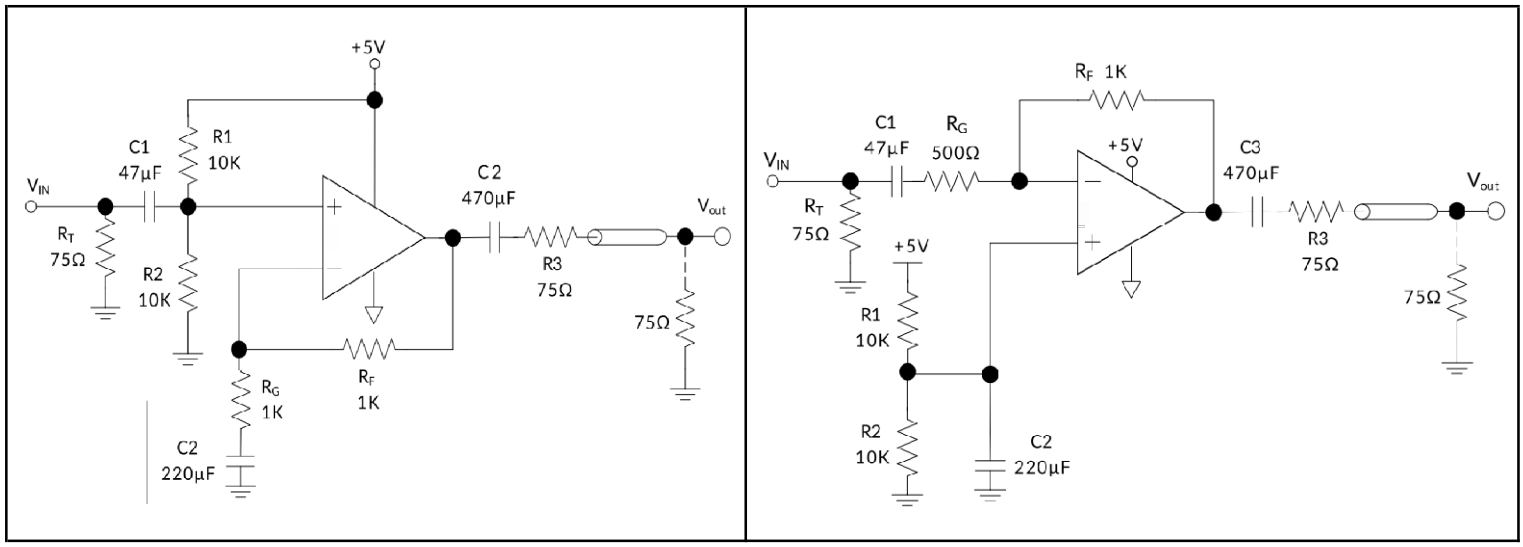
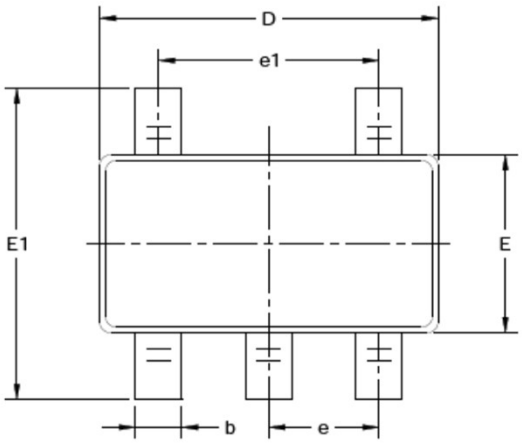
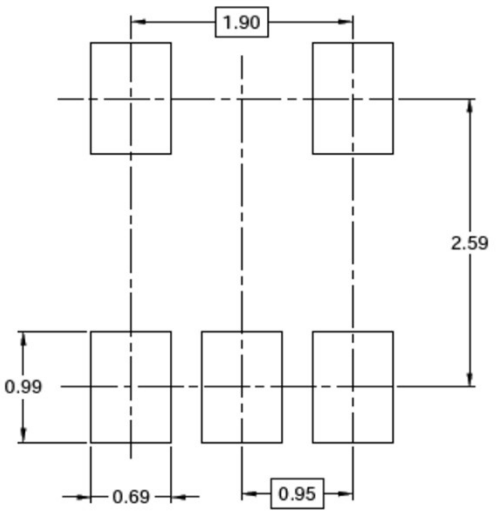


Figure 15. 5V Single Supply Non-Inverting and Inverting Video Line Driver

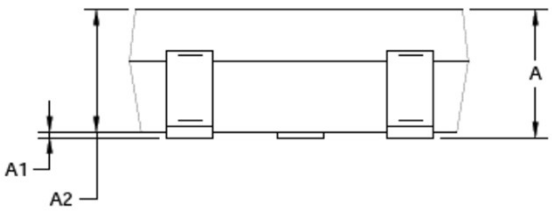
Mechanical Dimensions

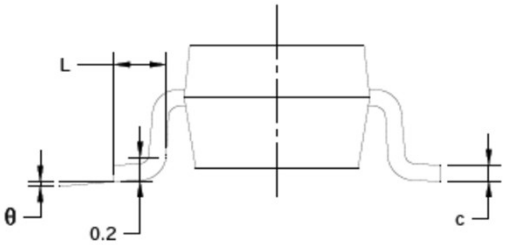
M5: SOT23-5 package





RECOMMENDED LAND PATTERN (Unit: mm)





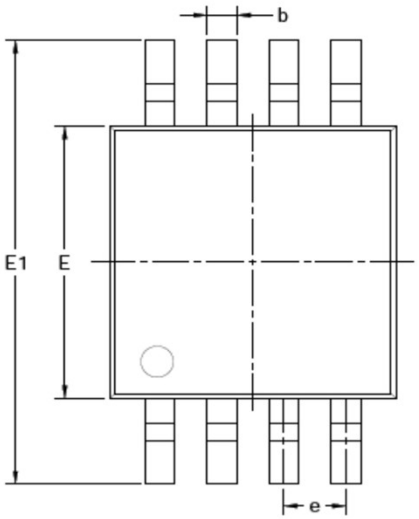
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

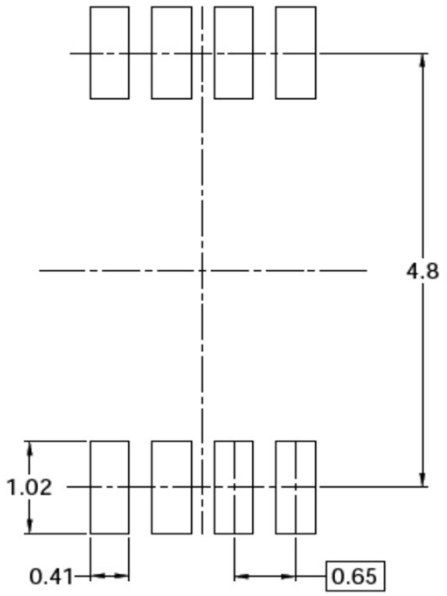
NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

250MHz, Rail-to-Rail Input/Output CMOS Operational Amplifier

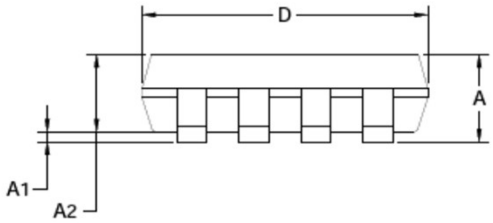
Mechanical Dimensions(Con.)

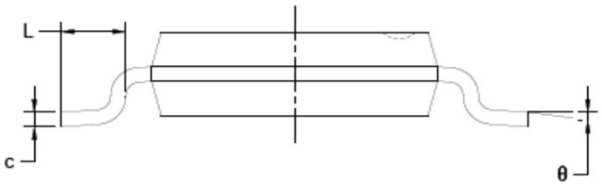
SM8: MSOP-8 Package





RECOMMENDED LAND PATTERN (Unit: mm)



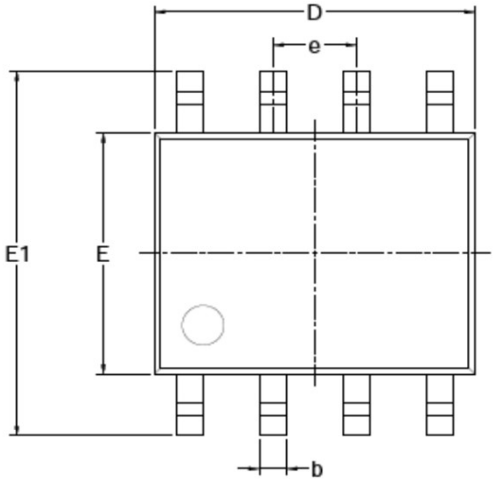


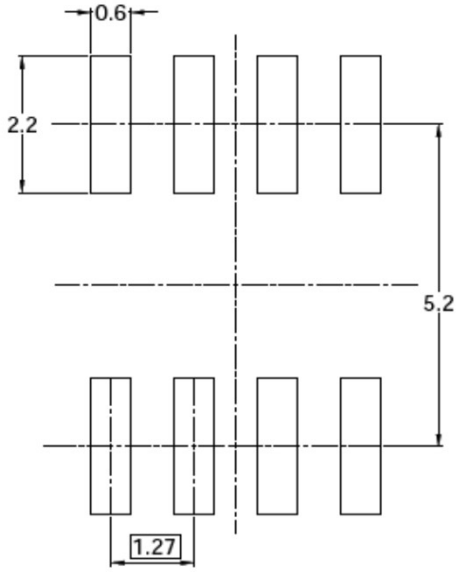
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

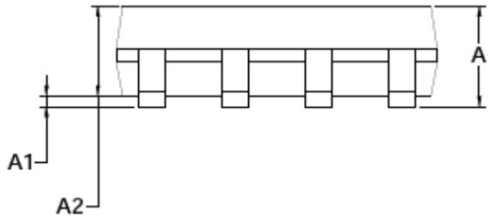
Mechanical Dimensions(Con.)

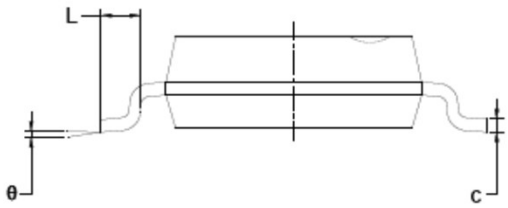
M8: SOIC-8(SOP-8) Package





RECOMMENDED LAND PATTERN (Unit: mm)



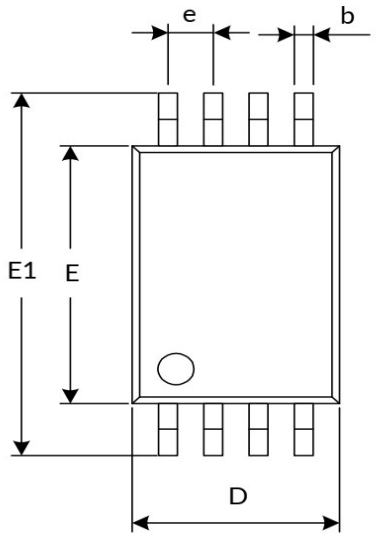


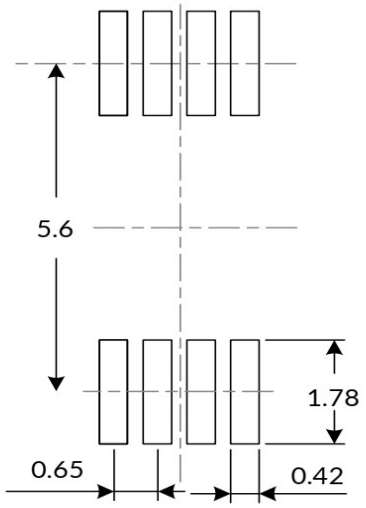
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

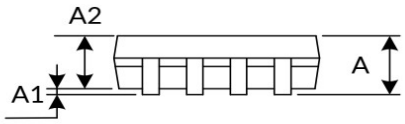
Mechanical Dimensions(Con.)

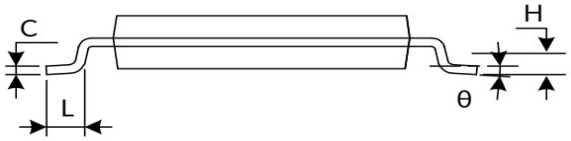
TS8: TSSOP-8 Package





RECOMMENDED LAND PATTERN (Unit: mm)



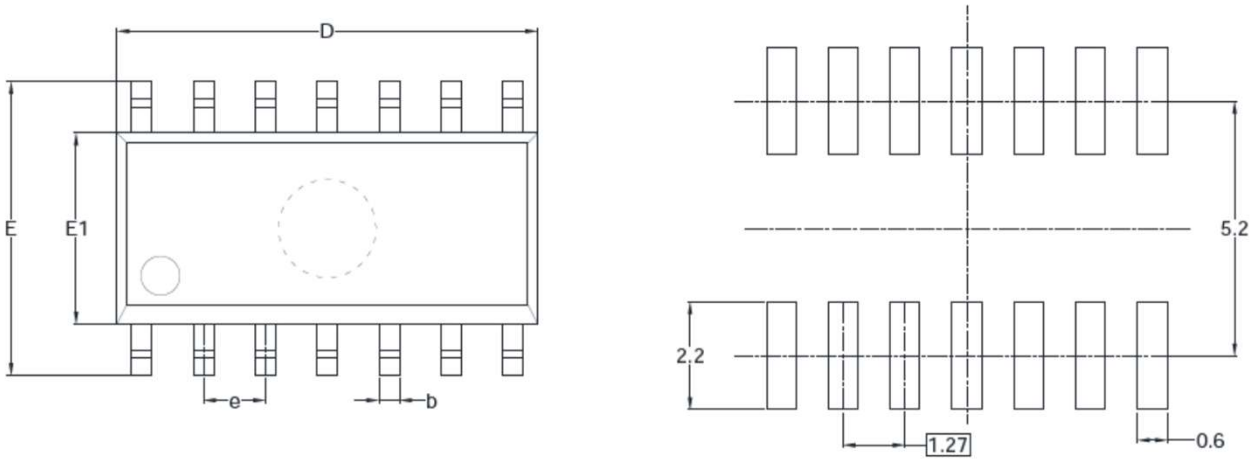


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D (1)	2.900	3.100	0.114	0.122
E (1)	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650(BSC) (2)		0.026(BSC) (2)	
L	0.500	0.700	0.020	0.028
H	0.25(TYP)		0.01(TYP)	
θ	1°	7°	1°	7°

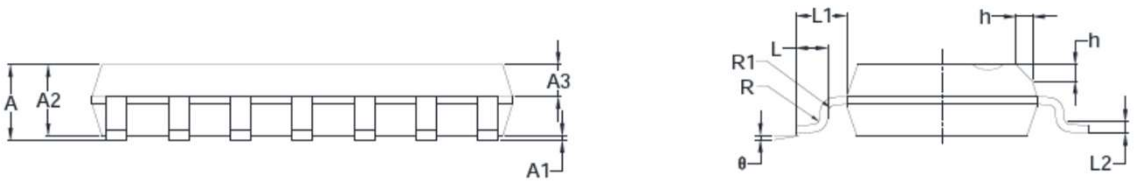
NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

Mechanical Dimensions(Con.)

M14: SOIC-14(SOP-14) Package



RECOMMENDED LAND PATTERN (Unit: mm)

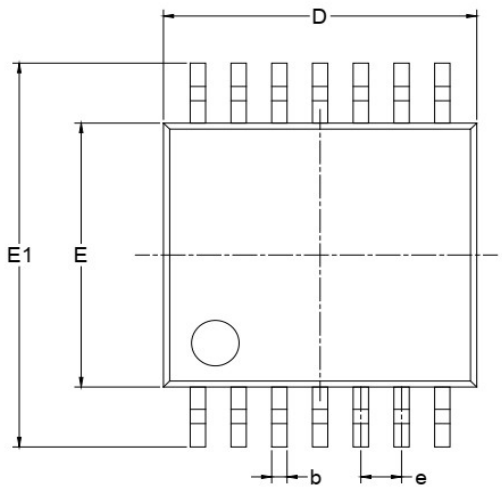


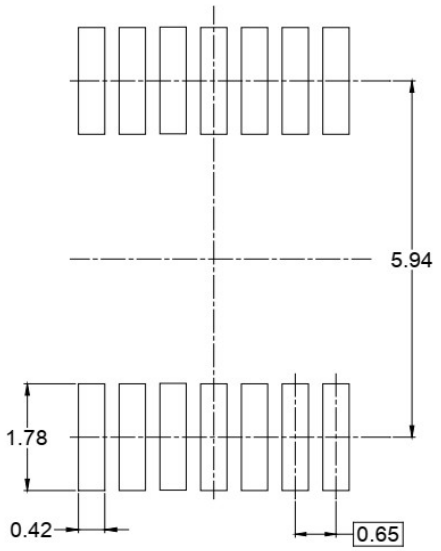
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.55	0.75	0.022	0.030
b	0.36	0.49	0.014	0.019
D	8.53	8.73	0.336	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
L	0.45	0.80	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.

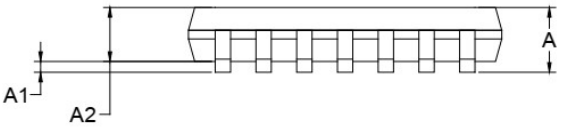
Mechanical Dimensions(Con.)

TS14: TSSOP-14 Package





RECOMMENDED LAND PATTERN (Unit: mm)

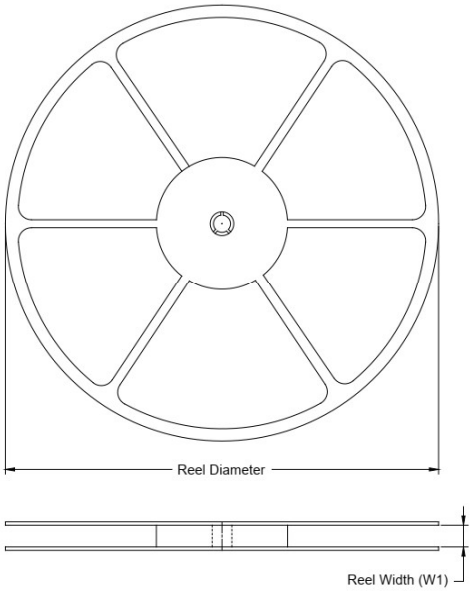


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.860	5.100	0.191	0.201
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500	0.700	0.02	0.028
H	0.25 TYP		0.01 TYP	
θ	1°	7°	1°	7°

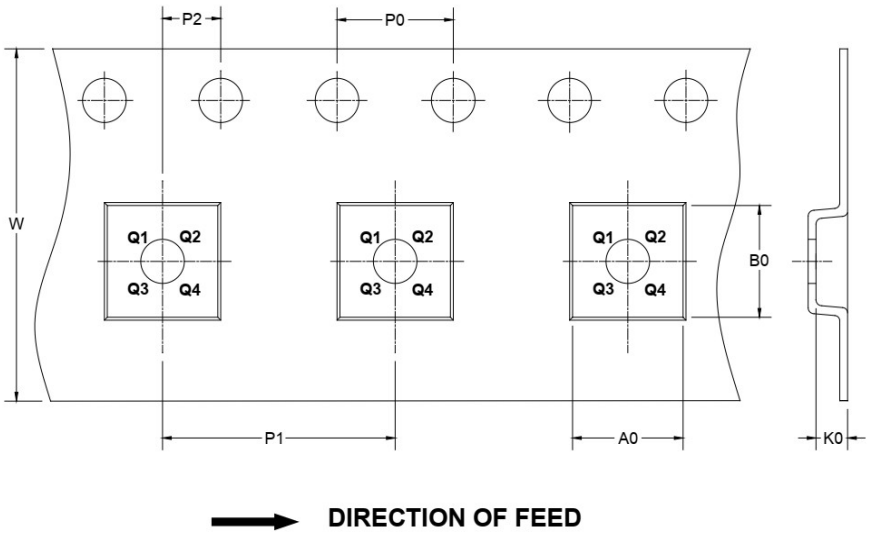
NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS

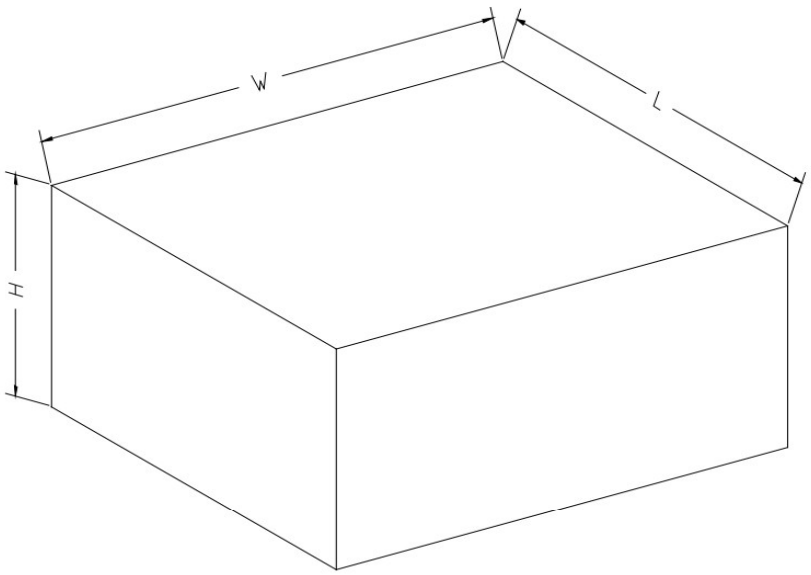


NOTE: The picture is only for reference. Please make the object as the standard.

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
TSSOP-8	13"	12.4	6.90	3.45	1.65	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
TSSOP-14	13"	12.4	6.95	5.60	1.20	4.0	8.0	2.0	12.0	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