HCR821/HCR822&HCR822S/HCR824

14MHz, Low Noise Rail-to-Rail I/O CMOS Operational Amplifier

Features

* High Gain Bandwidth : 14MHz
* Slew Rate: 10V/μs
* Input Offset Voltage: ±0.6mV(Typ.) V_{OS}
* Low Noise: 5.5nV/√Hz at 10KHz
* Rail-to-Rail Input and Output
* Supply Voltage Range: 2.5V to 5.5V
* Input Voltage Range: -0.1V to 5.6V with V_S = 5.5V
* Low Power:
  - HCR821: 1.9mA(Typ.)
  - HCR822&822S/HCR824:1.9mA/Amp(Typ.)
* Operating Temperature: -40'C to +125'C

Applications

* Active filter & Sensors
* Photodiode Amplification
* Test Equipment
* Driving A/D Converters
* Laptops and PDAs

General Description [note a]

The HCR821(single) /HCR822&HCR822S(dual) and HCR824 (quad) families of products offer low voltage operation and rail-to-rail input and output, as well as excellent speed/ power consumption ratio,providing an excellent bandwidth (14MHz) and slew rate of 10V/μs. The op-amps are unity gain stable and feature an ultra-low input bias current. The devices are ideal for sensor interfaces, active filters and portable applications. The HCR822S include a shut-down mode. Under logic control, the amplifiers can be switched from normal operation to a standby current that is less than 1μA. The HCR821/HCR822/HCR824 families of operational amplifiers are specified at the full temperature range of -40°C to +125°C under single or dual power supplies of 2.5V to 5.5V.

The HCR821 is available in SOT23-5, SOIC-8 packages.

The HCR822 is available in SOIC-8, MSOP-8 and TSSOP-8 Packages

The HCR822S is available in MSOP10 packages.

The HCR824 is available in SOIC-14, TSSOP-14 packages.

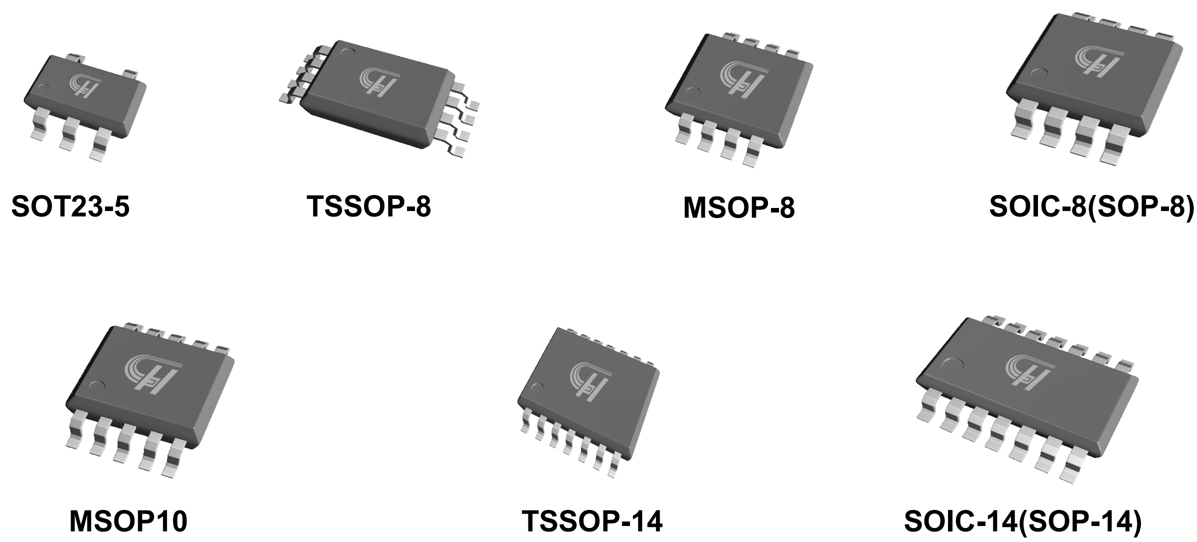


Figure 1. Package Type of HCR821/HCR822&HCR822S/HCR824

Pin Configuration

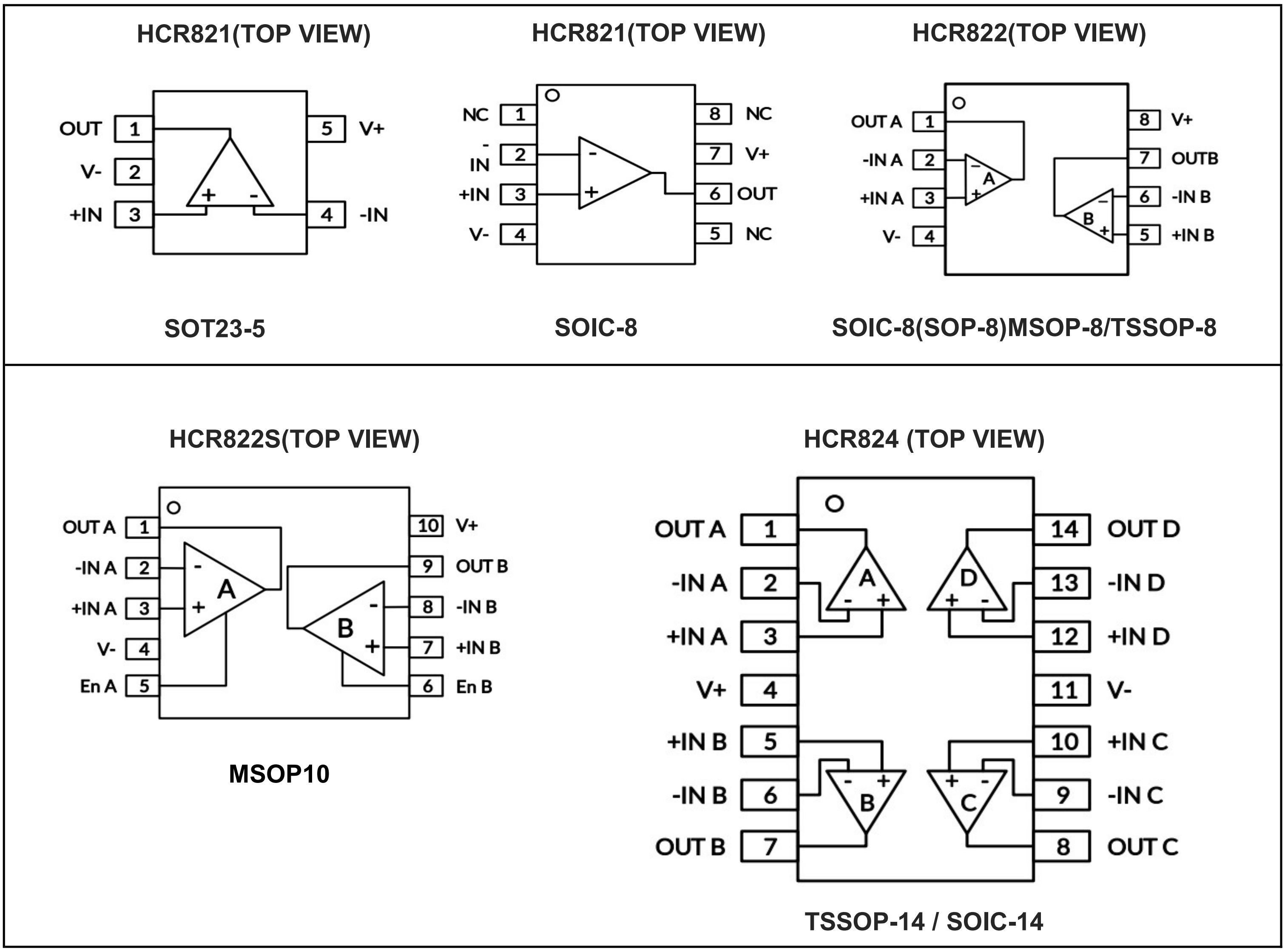


Figure 2. Pin Configuration of HCR821/HCR822&HCR822S/HCR824(Top View)

Pin Function Table

Name	Function
+IN, +INA, +INB, +INC, +IND	Non-inverting Inputs
-IN, -INA, -INB, -INC, -IND	Inverting Inputs
V+	Positive Power Supply
V-	Negative Power Supply
OUT, OUTA, OUTB, OUTC, OUTD	Outputs
EnA, EnB	Enable Pin, The Pin turns the regulator on or off. Low=disable, High=normal operation(pin must be driven)

14MHz, Low Noise Rail-to-Rail I/O CMOS Operational Amplifier

Ordering Information

Circuit Type □ □

Type:
HCR821
HCR822
HCR822S
HCR824

TR : Tape and Reel

Package:
M5:SOT23-5
SM8:MSOP-8
TS8: TSSOP8
M8: SOIC-8(SOP8)
SM10: MSOP10
M14: SOIC-14(SOP-14)
TS14: TSSOP-14

Ordering Code

Part Number	Channel	Marking [1]	Op Temp('C)	MSL [2]	Package	Package Qty
HCR821/M5TR	1	821	-40'C to +125'C	MSL3	SOT23-5	3000pcs/TR
HCR821/M8TR	1	HCR821xx	-40'C to +125'C	MSL3	SOIC-8 (SOP-8)	4000pcs/TR
HCR822/SM8TR	2	HCR822xx	-40'C to +125'C	MSL3	MSOP-8	4000pcs/TR
HCR822/TS8TR	2	HCR822xx	-40'C to +125'C	MSL3	TSSOP8	4000pcs/TR
HCR822/M8TR	2	HCR822xx	-40'C to +125'C	MSL3	SOIC-8 (SOP-8)	4000pcs/TR
HCR822S/SM8TR	2	HCR822Sxx	-40'C to +125'C	MSL3	MSOP10	4000pcs/TR
HCR824/M14TR	4	HCR824xx	-40'C to +125'C	MSL3	SOIC-14 (SOP-14)	4000pcs/TR
HCR824/TS14TR	4	HCR824xx	-40'C to +125'C	MSL3	TSSOP-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.

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[2]		VIN	(V-) -0.5	(V+) +0.5	V
Signal Output Voltage[3]		Vout	(V-) -0.5	(V+) +0.5	V
Signal Input Current[2]		IIN	-10	+10	mA
Signal Output Current[3]		IO	-140	+140	mA
Output Short-circuit [4]		-	Continuous		-
Thermal Resistance @TA=+25'C [5]	SOT23-5	θJA	230		'C/W
	SOIC-8 (SOP8)	θJA	110		'C/W
	MSOP-8	θJA	170		'C/W
	TSSOP-8	θJA	240		'C/W
	MSOP10	θJA	200		'C/W
	SOIC-14	θJA	90		'C/W
	TSSOP-14	θJA	105		'C/W
Operating Temperature Range note 2		TOPR	-40 to +125		'C
Junction Temperature [6]		TJ	+150		'C
Storage Temperature Range		TSTG	-65 to +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].Output terminals are diode-clamped to the power-supply rails. Output signals that can swing more than 0.5V beyond the supply rails should be current-limited to ±140mA or less.

[4]. Short-circuit to ground, one amplifier per package.

[5]. The package thermal impedance is calculated in accordance with JESD-51.

[6].The maximum power dissipation is a function of TJ(MAX), RθJA, and TA. The maximum allowable power dissipation at any ambient temperature is $P_D=(T_{J(MAX)} - T_A) / R_{\theta JA}$. 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	2.5	5.5	V
	Dual-supply		±1.25	±2.75	V
Operating Temperature Range		Ta	-40	+125	'C

14MHz, Low Noise Rail-to-Rail I/O CMOS Operational Amplifier

Electrical Characteristics

(TA=25`C, Vs=+5V, RL=10KΩ connected to Vs/2, and VOUT=Vs/2. VCM=Vs/2, Full[9]=-40'C to 125'C, Unless Otherwise noted.)[1]

Parameter	Symbol	Conditions	Temp	Min[2]	Typ.[3]	Max[2]	Unit
Input Characteristics							
Input Offset Voltage	VOS	VCM =VS /2	25'C	-2.5	±0.6	2.5	mV
Input Offset Voltage Average Drift	VOS TC	VCM =VS /2	Full	-	±1.6	-	uV/'C
Input Bias Current [4][5]	IB		25'C	-	±1	±10	pA
Input Offset Current [4]	IOS		25'C	-	±1	±10	pA
Common-Mode Voltage Range	VCM	VS=5.5V	25'C	-0.1	-	+5.6	V
Common Mode Rejection Ratio	CMRR	VS=5.5V, VCM= -0.1V to 4V	25'C	75	88	-	dB
			Full	67	-	-	
		VS=5.5V, VCM= -0.1V to 5.6V	25'C	61	75	-	
			Full	58	-	-	
Output Characteristics							
Open-Loop Voltage Gain	AOL	RL=2KΩ, Vout=+0.15V to 4.85V	25'C	91	100	-	dB
			Full	78	-	-	
		RL=10KΩ, Vout=+0.05V to 4.95V	25'C	89	98	-	
			Full	75	-	-	
Output Voltage Swing from Rail	VOH	RL=2KΩ	25'C	-	20	-	mV
	VOL	RL=10KΩ	25'C	-	7	-	
Output Short-Circuit Current[6][7]	Iout	-	25'C	-	±110	-	mA
Power Supply							
Operating Voltage Range	VS		25'C	2.5	-	5.5	V
Quiescent Current per Amplifier	IQ		25'C	-	1.9	2.5	mA
Power Supply Rejection Ratio	PSRR	VS=2.5V to 5.5V, VCM =(V-)+0.5V	25'C	75	88	-	dB
			Full	65	-	-	
FREQUENCY RESPONSE							
Gain Bandwidth Product	GBP	-	25'C	-	14	-	MHz
Phase Margin	Øo	-	25'C	-	58	-	°
Slew Rate [8]	SR	-	25'C	-	10	-	V/us
Settling Time to 0.1%	ts	-	25'C	-	0.2	-	us
Overload Recovery Time		VINxGain>=VS	25'C	-	0.3	-	us

Electrical Characteristics (con.)

(TA=25˚C, Vs=+5V, RL=10KΩ connected to Vs/2, and VOUT=Vs/2. Full=-40'C to 125'C, Unless Otherwise Specified.)

Parameter	Symbol	Conditions	Temp	Min	Type	Max	Unit
Noise Performance							
Input Voltage Noise Density	en	f=1KHz	25'C	-	8.5	-	nV/√Hz
		f=10KHz	25'C	-	5.5	-	nV/√Hz
ENABLE/SHUTDOWN(HCR822S)							
Supply Current in Shutdown	$I_{Q(OFF)}$	-	25'C	-	<1	-	uA
	t_{OFF}	-	25'C	-	3	-	us
	t_{ON}	-	25'C	-	20	-	us
Shut Down	V_L	-	25'C	V-	0.2	(V-) +0.8	V
Amplifier Is Active	V_H	-	25'C	(V-) +2	-	V+	V

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 $P_D = (T_{J(MAX)} - T_A) / R_{\theta JA}$. 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.

(At TA = +25°C, Vs=5V, RL = 10kΩ connected to VS/2, VOUT = VS/2, unless otherwise noted.)

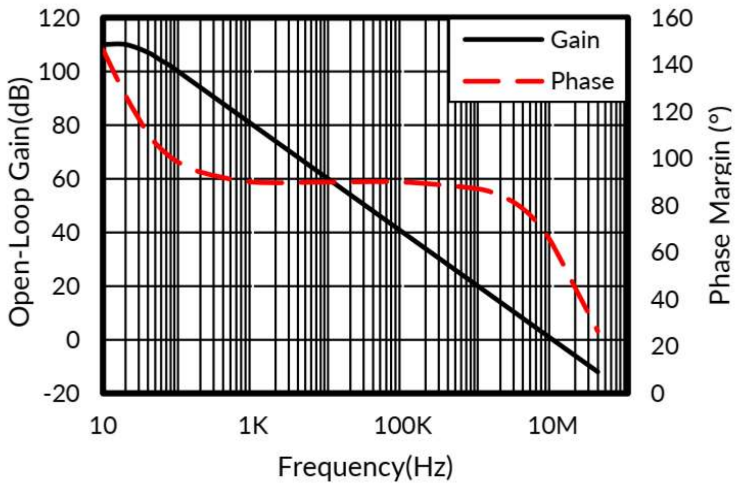


Figure 3. Open-Loop Gain and Phase vs Frequency

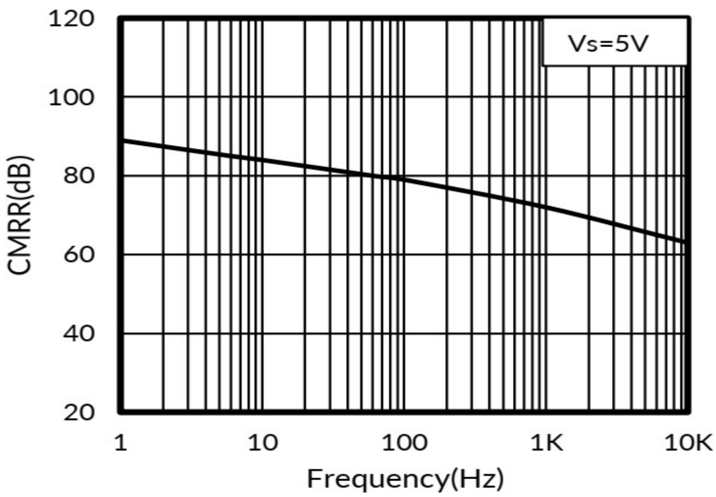


Figure 4. Common-Mode Rejection Ratio vs Frequency

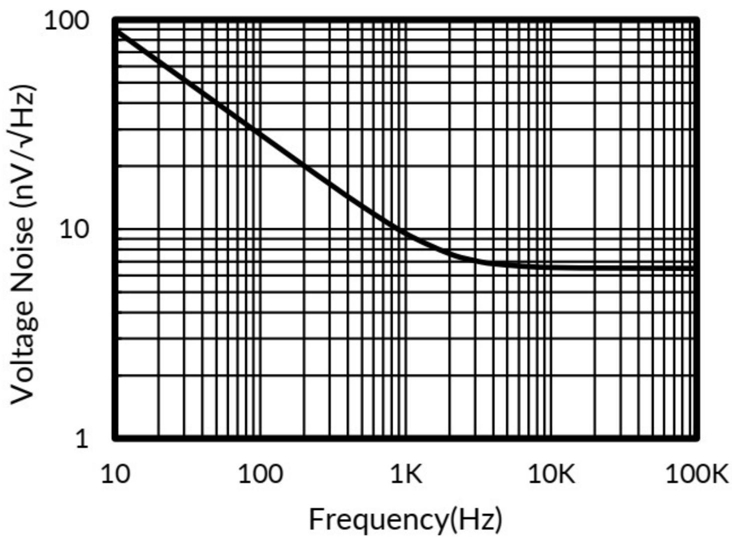


Figure 5. Input Voltage Noise Spectral Density vs Frequency

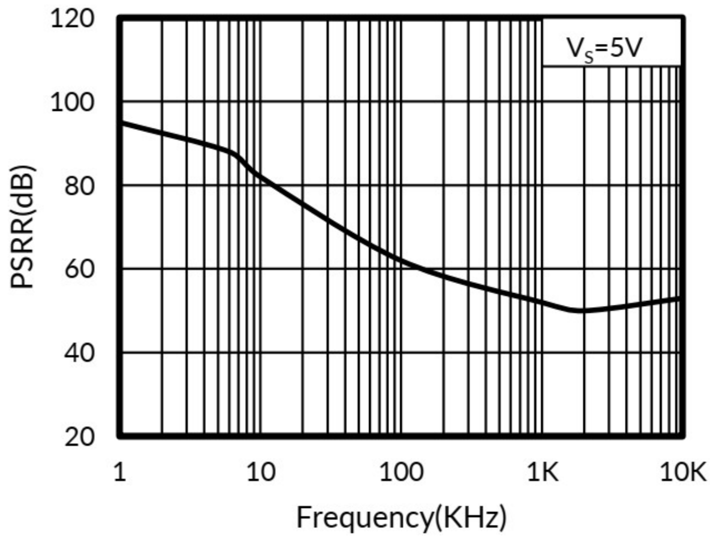


Figure 6. Power-Supply Rejection Ratio vs Frequency

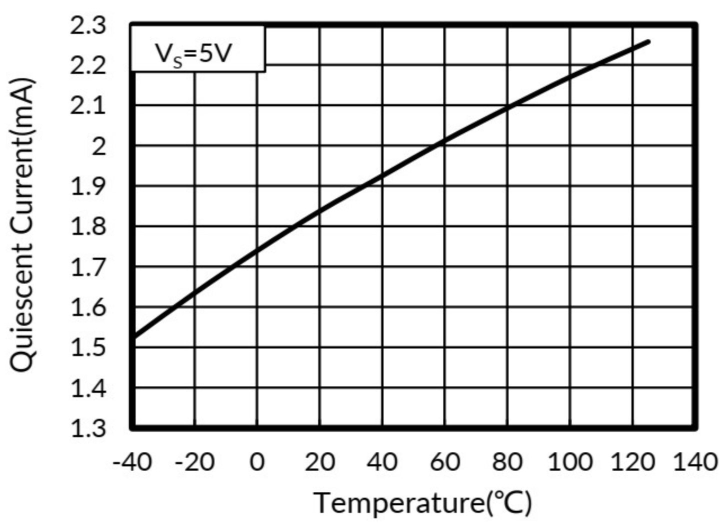


Figure 7. Quiescent Current vs Temperature

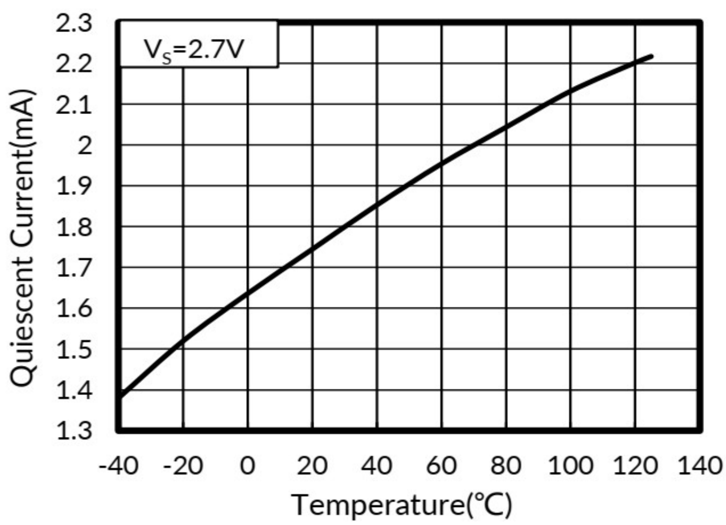


Figure 8. Quiescent Current vs Temperature

Typical Performance Characteristics(con.)

(At TA = +25°C, Vs=5V, RL = 10kΩ connected to VS/2, VOUT = VS/2, unless otherwise noted.)

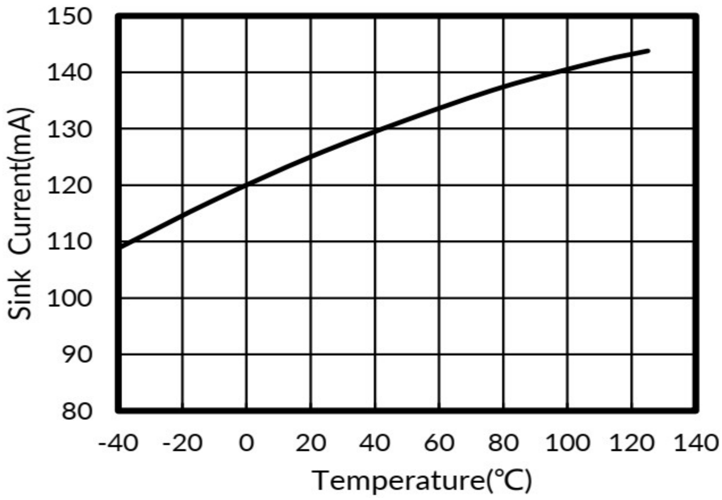


Figure 9. Sink Current vs Temperature

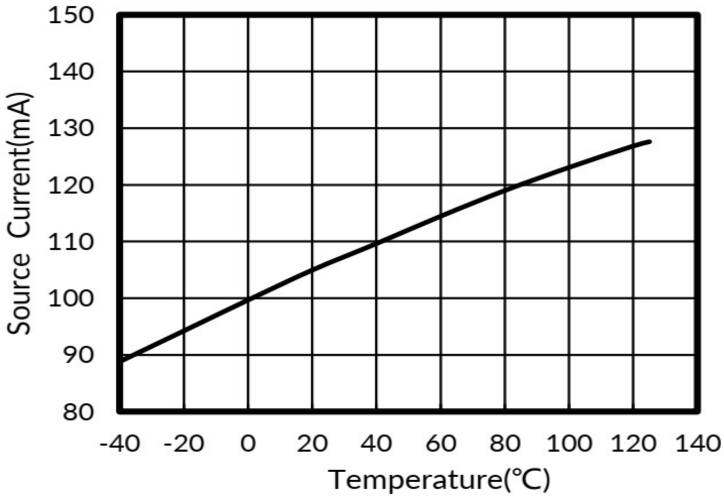


Figure 10. Source Current vs Temperature

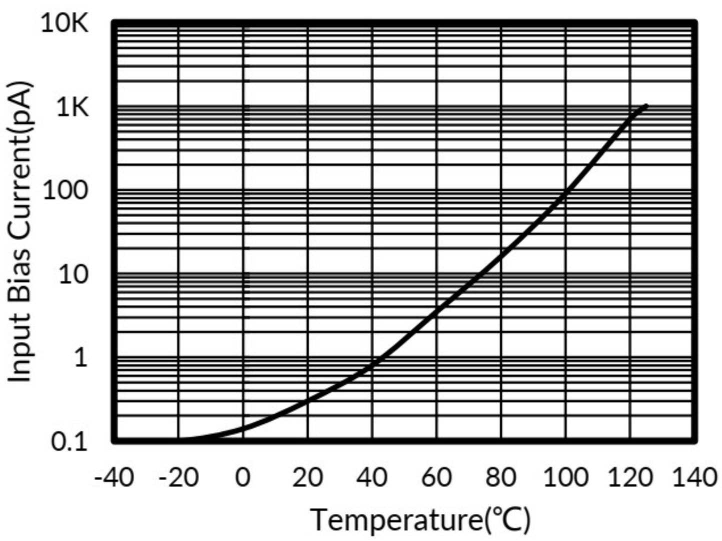


Figure 11. Input Bias Current vs Temperature

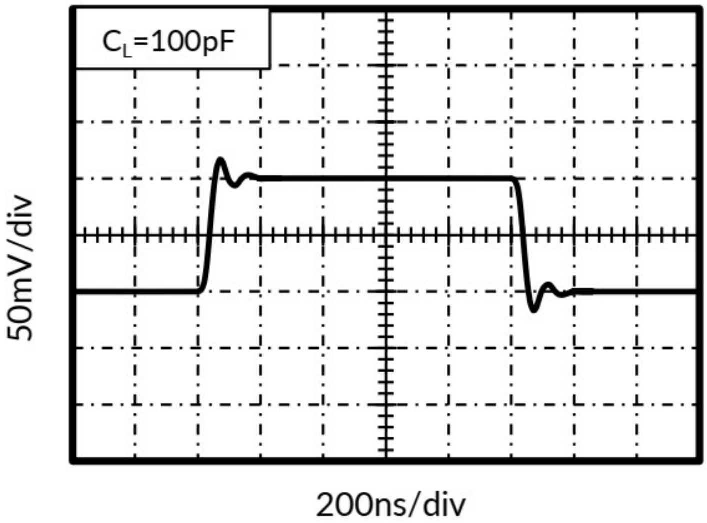


Figure 12. Small-Signal Step Response

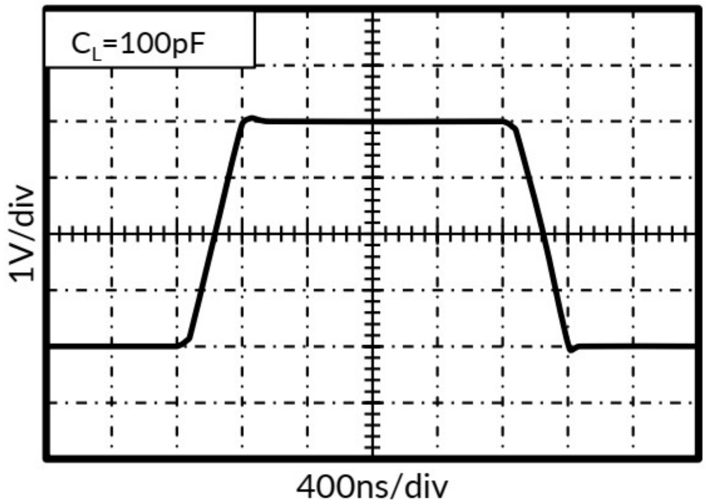


Figure 13. Large-Signal Step Response

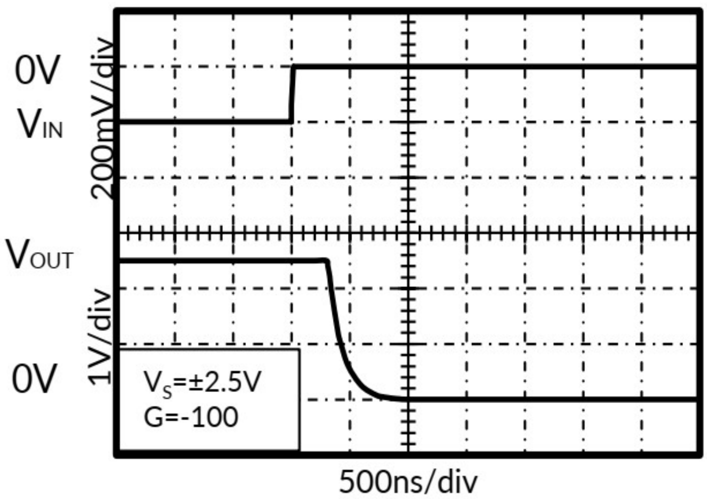


Figure 14. Positive Overvoltage Recovery

Typical Performance Characteristics(con.)

(At TA = +25°C, Vs=5V, RL = 10kΩ connected to VS/2, VOUT = VS/2, unless otherwise noted.)

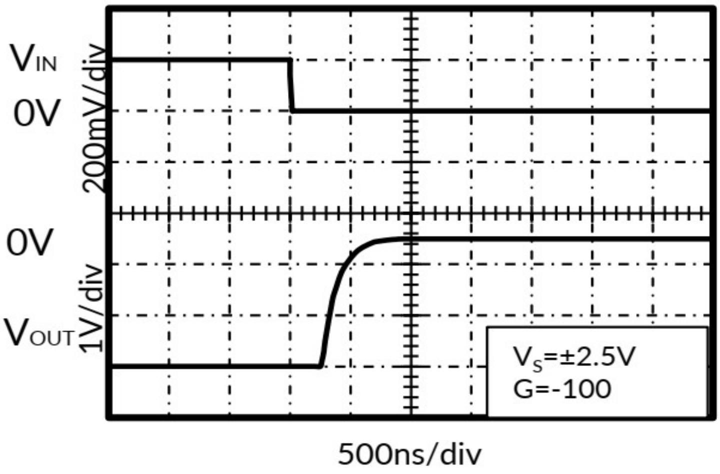


Figure 15. Negative Overvoltage Recovery

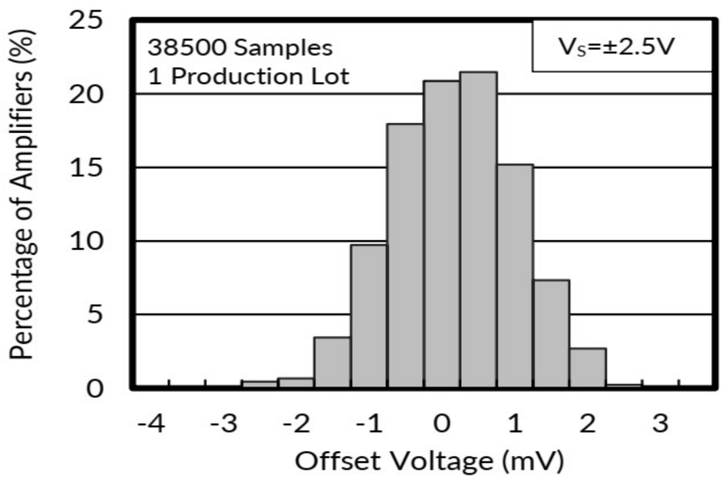


Figure 16. Offset Voltage Production Distribution

Detailed Description

Overview

The HCR821, HCR822, HCR824, HCR822S are high precision, rail-to-rail operational amplifiers that can be run from a single supply voltage 2.5V to 5.5V(±1.25V to ±2.75V). Supply voltages higher than 7V (absolute maximum) can permanently damage the amplifier. Rail-to-rail input and 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.

HCR822S Enable Function

The HCR822S includes a shutdown mode. Under logic control, the amplifiers can be switched from normal mode to a standby current of 1μA. When the Enable pin is connected to high, the amplifier is active. Connecting Enable low disables the amplifier, and places the amplifier, and place the output in a high-impedance state.

Phase Reversal Protection

The HCR821/HCR822&HCR822S/HCR824 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 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 HCR821 /HCR822&HCR822S /HCR824 prevents phase reversal with excessive common-mode voltage. Instead, the appropriate rail limits the output voltage. This performance is shown in figure 17.

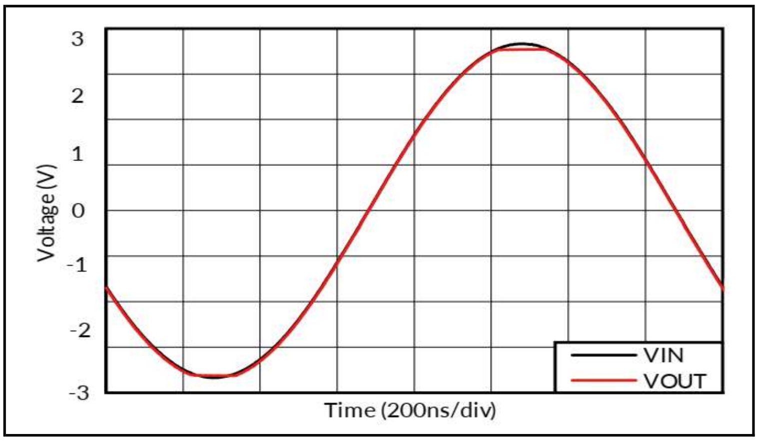


Figure 17. Output Waveform Devoid of Phase Reversal During an Input Overdrive Condition

EMI Rejection Ratio (EMIRR)

The electromagnetic interference (EMI) rejection ratio, or EMIRR, describes the EMI immunity of operational amplifiers. An adverse effect that is common to many operational amplifiers is a change in the offset voltage

Detailed Description(con)

EMI Rejection Ratio (EMIRR)(con.)

as a result of RF signal rectification. An operational amplifier that is more efficient at rejecting this change in offset as a result of EMI has a higher EMIRR and is quantified by a decibel value. Measuring EMIRR can be performed in many ways, but this document provides the EMIRR IN+,which specifically describes the EMIRR performance when the RF signal is applied to the noninverting input pin of the operational amplifier.

In general, only the noninverting input is tested for EMIRR for the following three reasons:

- Operational amplifier input pins are known to be the most sensitive to EMI, and typically rectify RF signals better than the supply or output pins.
- The noninverting and inverting operational amplifier inputs have symmetrical physical layouts and exhibit nearly matching EMIRR performance.
- EMIRR is easier to measure on noninverting pins than on other pins because the noninverting input pin can be isolated on a printed-circuit-board (PCB). This isolation allows the RF signal to be applied directly to the noninverting input pin with no complex interactions from other components or connecting PCB traces.

The EMIRR IN+ of the HCR821 /HCR822&HCR822S /HCR824 is plotted versus frequency in Figure 18. If available,any dual and quad operational amplifier device versions have approximately identical EMIRR IN+ performance. The HCR821/HCR822&HCR822S /HCR824 unity-gain bandwidth is 14MHz. EMIRR performance below this frequency denotes interfering signals that fall within the operational amplifier bandwidth.

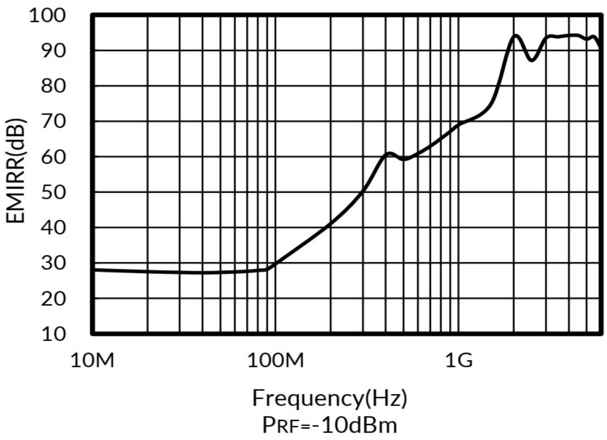


Figure 18. HCR821/HCR822&HCR822S/HCR824 EMIRR vs Frequency

EMIRR IN+ Test Configuration

Figure 19 shows the circuit configuration for testing the EMIRR IN+. RF source is connected to the operational amplifier noninverting input pin using a transmission line. The operational amplifier is configured in a unity-gain buffer topology with the output connected to a low-pass filter (LPF) and a digital multimeter (DMM).

A large impedance mismatch at the operational amplifier input causes a voltage reflection; however, this effect is characterized and accounted for when determining the EMIRR IN+. The resulting dc offset voltage is sampled and measured by the multimeter. The LPF isolates the multimeter from residual RF signals that can interfere with multimeter accuracy.

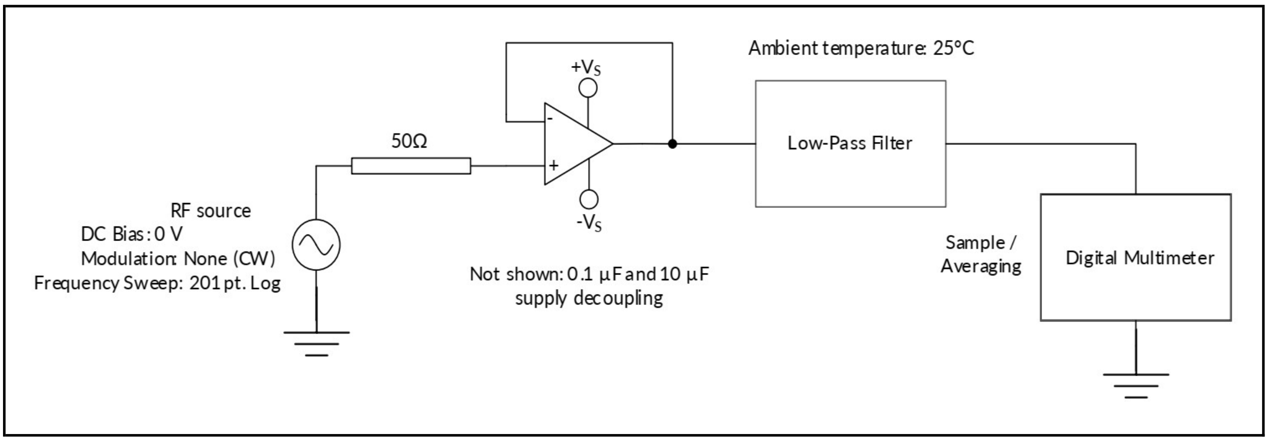


Figure 19. EMIRR IN+ Test Configuration Schematic

Application Note

The HCR821/HCR822&HCR822S/HCR824 are high precision, rail-to-rail operational amplifiers that can be run from a single-supply voltage 2.5V to 5.5V(±1.25V to ±2.75V). Supply voltages higher than 7V (absolute maximum) can permanently damage the amplifier. Rail-to-rail input and 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.

Typical Applications

25-kHz Low-pass Filter

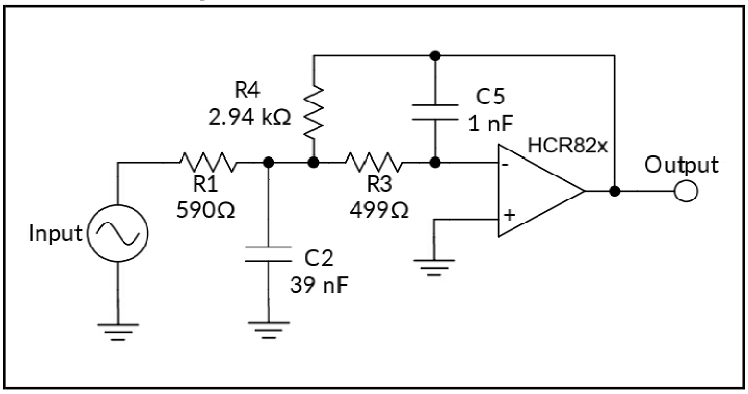


Figure 20. 25-kHz Low-pass Filter

Design Requirements

Low-pass filters are commonly employed in signal processing applications to reduce noise and prevent aliasing.

The HCR821/HCR822&HCR822S/HCR824 devices are ideally suited to construct high-speed, high-precision active filters.Figure 20 shows a second-order, low-pass filter commonly encountered in signal processing applications. 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 20. Use Equation 1 to calculate the voltage transfer function.

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

This circuit produces a signal inversion. For this circuit, the gain at dc and the low-pass cutoff frequency are calculated by Equation 2:

$$Gain = \frac{R_4}{R_1} \quad (2)$$

$$f_C = \frac{1}{2\pi}\sqrt{(1/R_3R_4C_2C_5)}$$

Application Curve

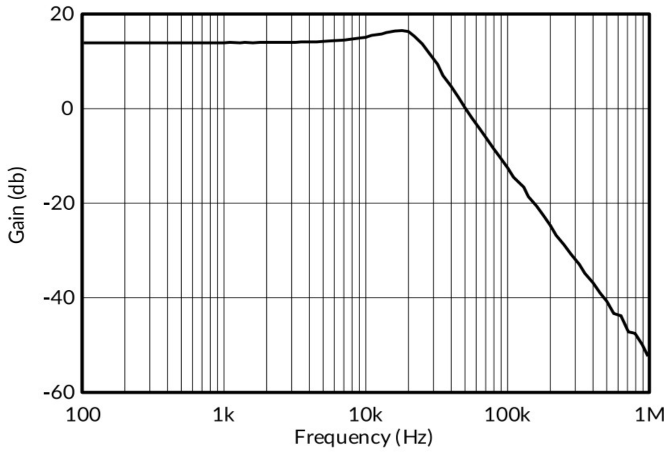


Figure 21. Low-Pass Filter Transfer Function

Layout Guidelines

Attention to good layout practices is always recommended. Keep traces short. When possible, use a PCB ground plane with surface-mount components placed as close to the device pins as possible. Place a 0.1μF capacitor closely across the supply pins. These guidelines should be applied throughout the analog circuit to improve performance and provide benefits such as reducing the EMI susceptibility.

Layout Example

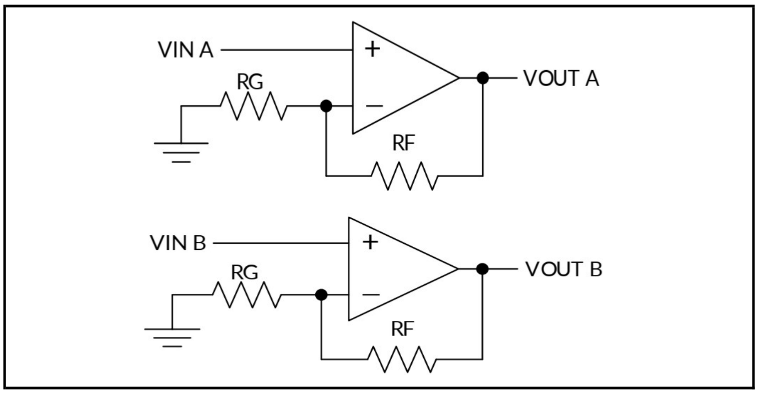
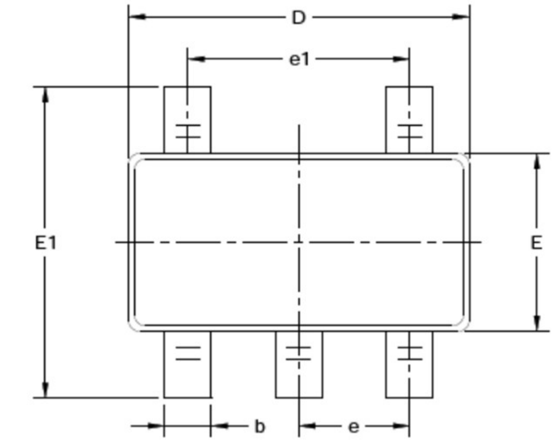
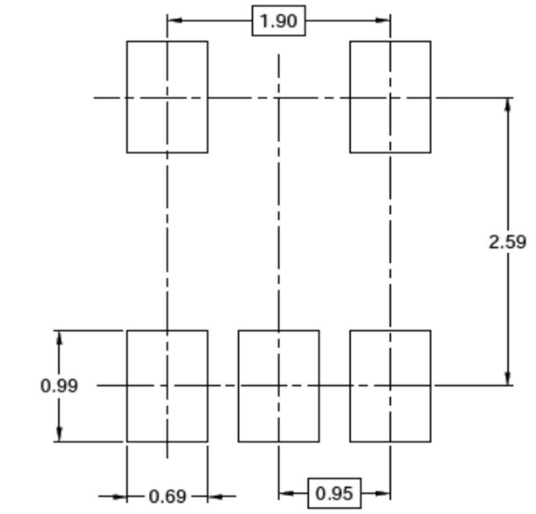


Figure 22. Schematic Representation

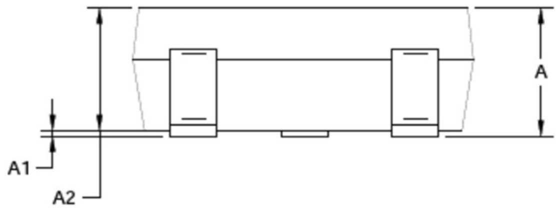
Mechanical Dimensions

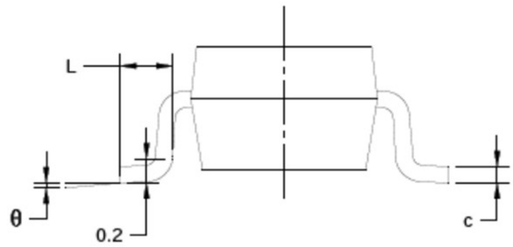
M5: SOT23-5 package





RECOMMENDED LAND PATTERN (Unit: mm)



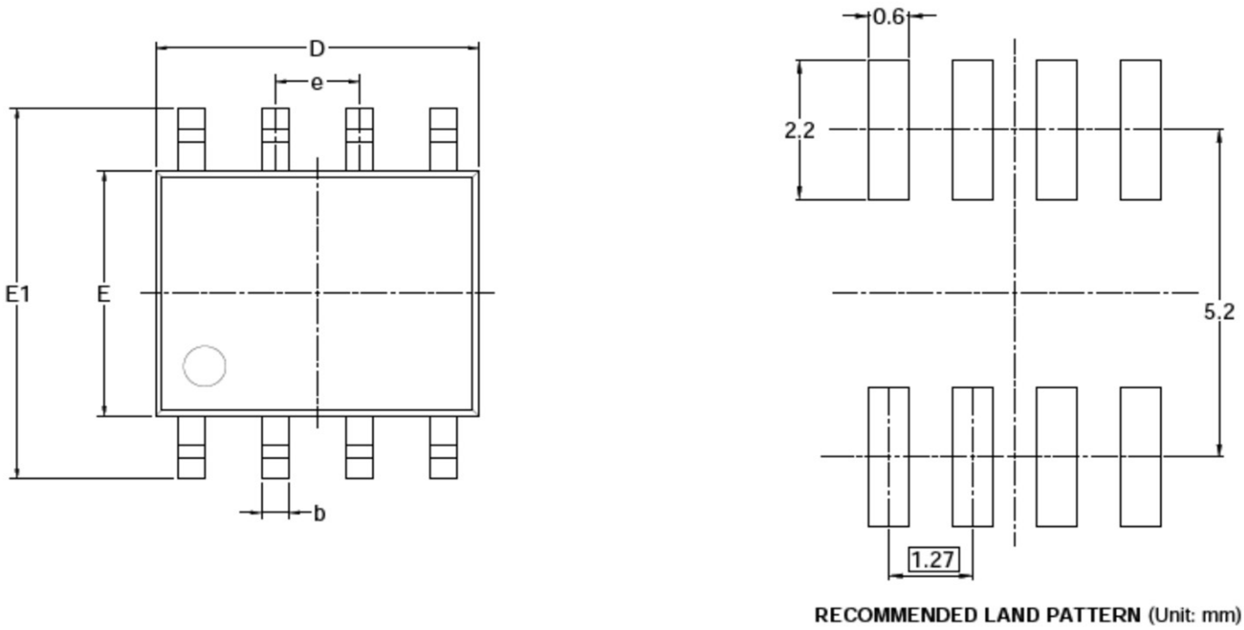


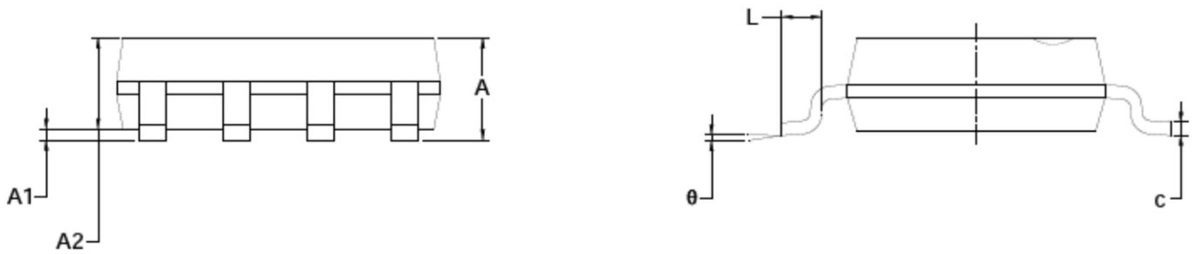
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 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.)

M8: SOIC-8(SOP-8) Package



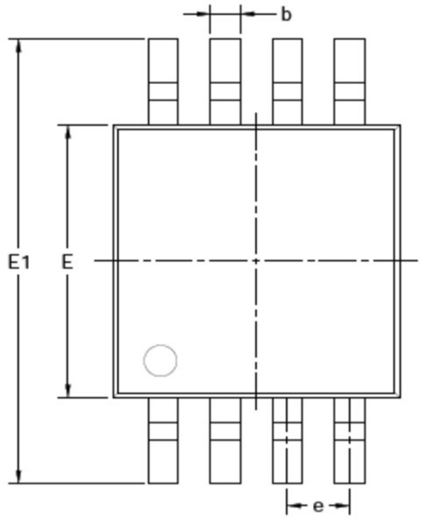


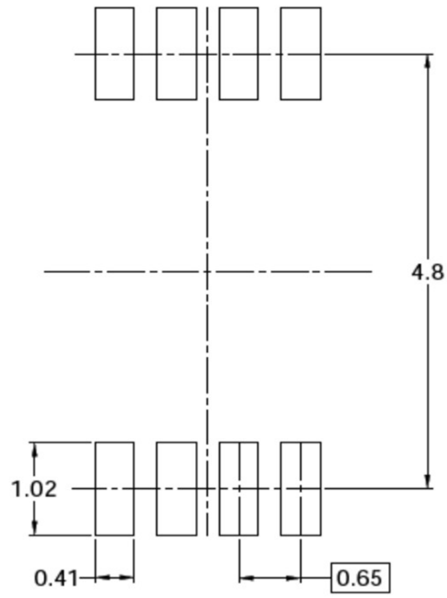
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

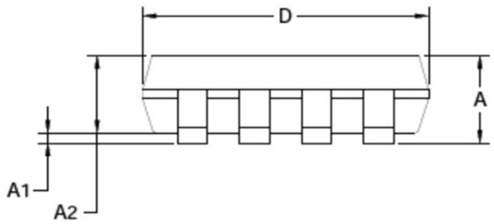
Mechanical Dimensions(Con.)

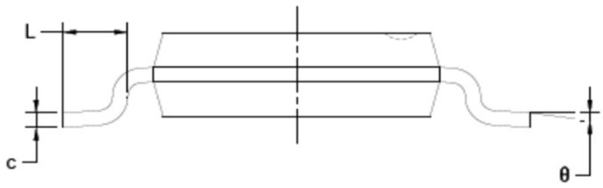
MS8: MSOP-8 Package





RECOMMENDED LAND PATTERN (Unit: mm)



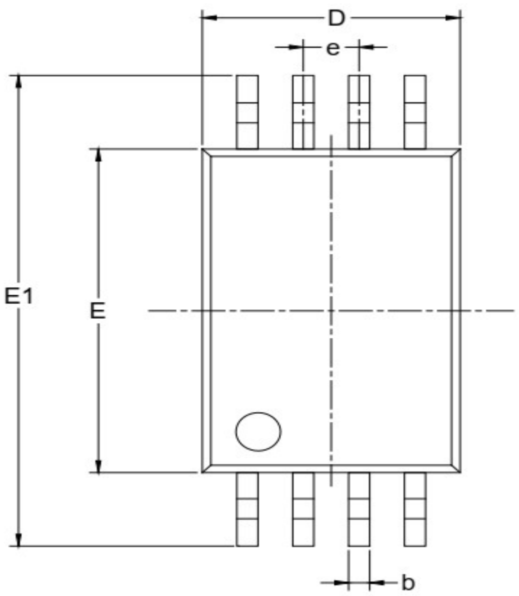


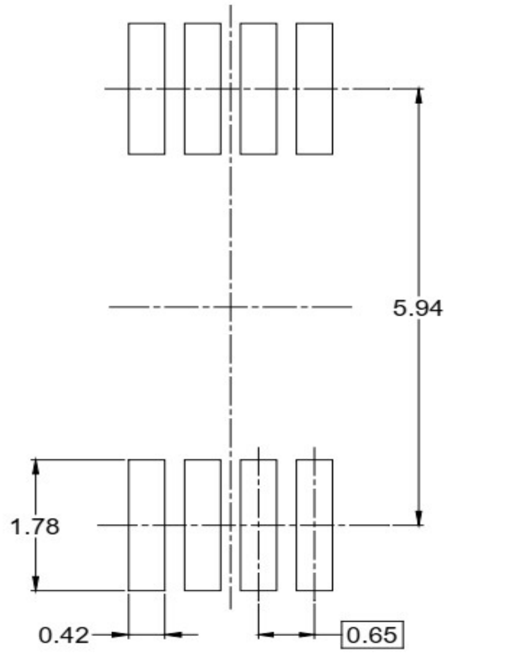
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

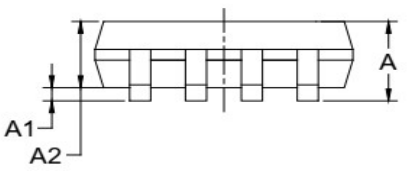
Mechanical Dimensions(Con.)

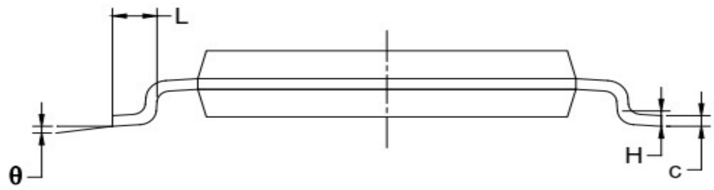
TS8: TSSOP-8 Package





RECOMMENDED LAND PATTERN (Unit: mm)



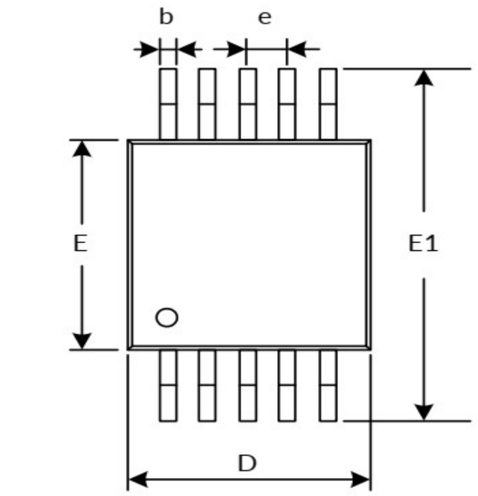


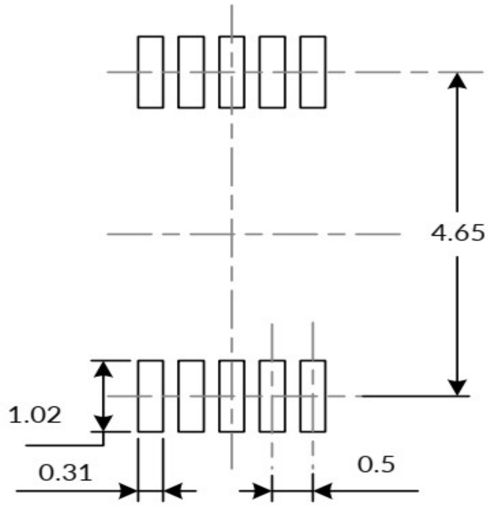
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.100		0.043
A1	0.050	0.150	0.002	0.006
A2	0.800	1.000	0.031	0.039
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	2.900	3.100	0.114	0.122
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500	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.

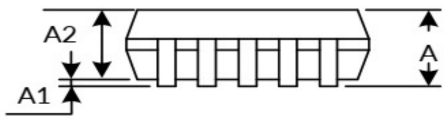
Mechanical Dimensions(Con.)

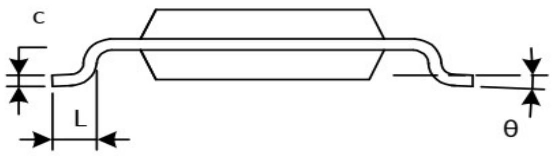
MS10: MSOP10 Package





RECOMMENDED LAND PATTERN (Unit: mm)



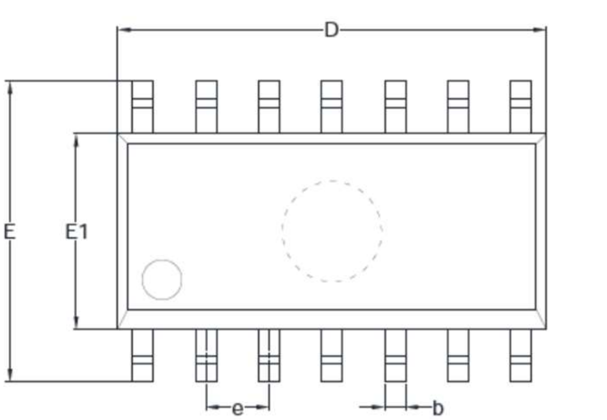


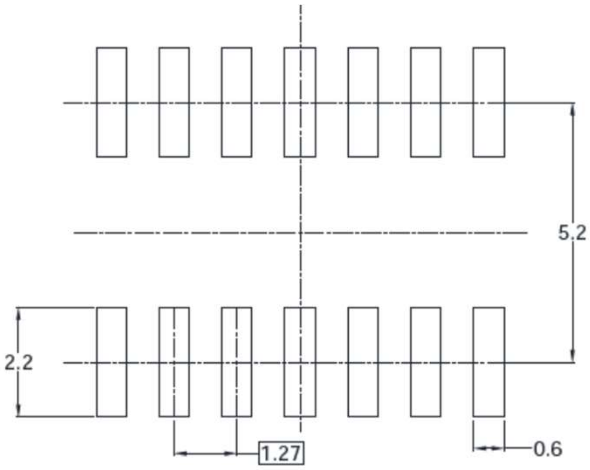
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.180	0.280	0.007	0.011
c	0.090	0.230	0.004	0.009
D (1)	2.900	3.100	0.114	0.122
e	0.50(BSC) (2)		0.020(BSC) (2)	
E (1)	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
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.

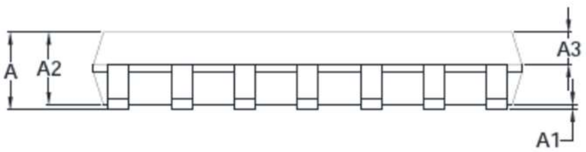
Mechanical Dimensions(Con.)

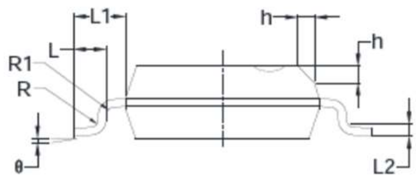
M14: SOIC-14 Package





RECOMMENDED LAND PATTERN (Unit: mm)



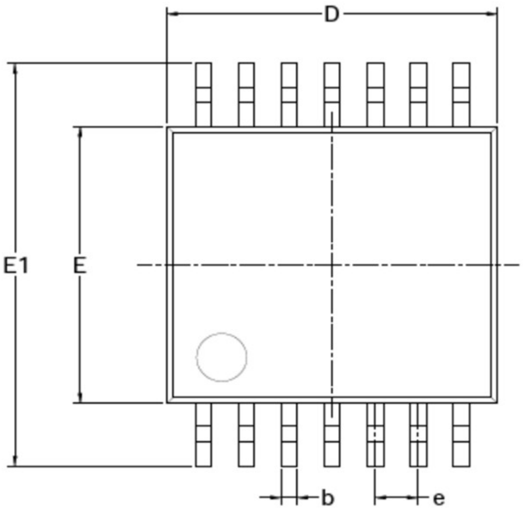


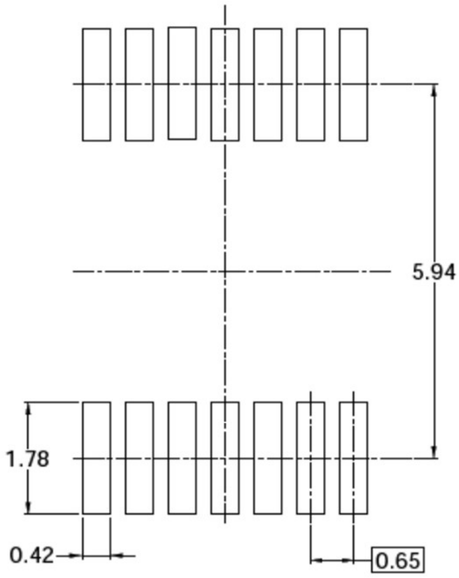
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.55	0.75	0.022	0.030
b	0.36	0.49	0.014	0.019
D	8.53	8.73	0.336	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
L	0.45	0.80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

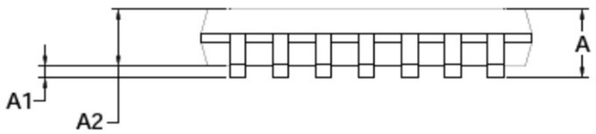
NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

Mechanical Dimensions(Con.)

TS14: TSSOP-14 Package





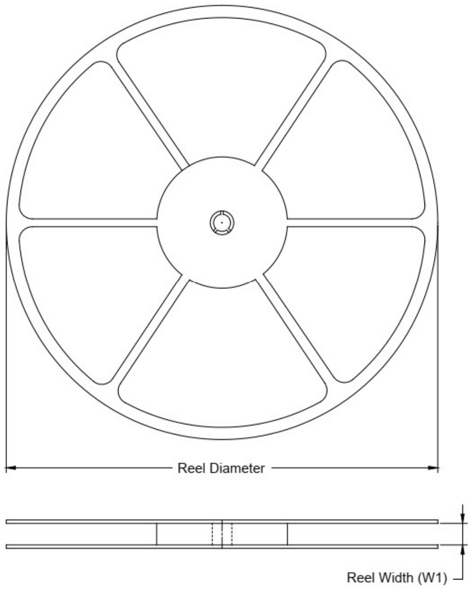


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.860	5.100	0.191	0.201
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500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

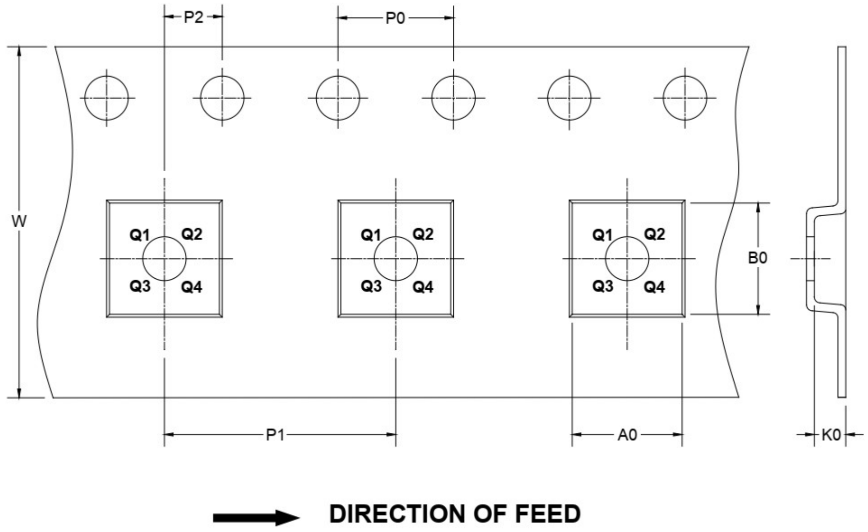
NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

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 (SOP-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
MSOP-10	13"	12.4	5.20	3.30	1.20	4.0	8.0	2.0	12.0	Q1
SOIC-14 (SOP-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

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