6.5MHz, Rail-to-Rail I/O CMOS Operational Amplifier

Features

- Low power consumption: 670μA at 5 V
- Low power shutdown mode:1μA max
- Low offset voltage: 3mV max at 25°C
- Rail-to-rail input/output
- Gain bandwidth product: 6.5MHz
- Extended temperature : -40°C to +125°C
- Low supply voltage: +2.7 V to +5.5 V

Applications

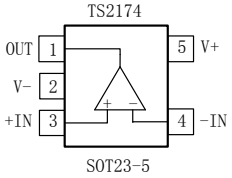
- Battery-powered applications
- Portable devices
- Signal conditioning
- Active filtering
- Current sensor amplifier
- Weight Scale sensor
- Medical/ Industrial instrumentation
- Instrumentation
- Inverter

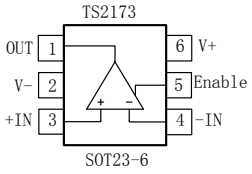
Product Description

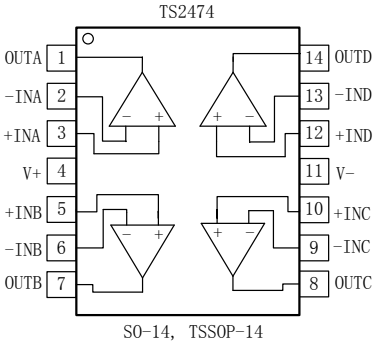
The TS2173/TS2174 families are low noise, low voltage, and low power operational amplifiers. The operating range is from 2.7V to 5.5V.They have a high gain-bandwidth product of 6.5MHz, a slew rate of 5V/μs, and a quiescent current of 670μA/amplifier at 5V.They provide rail-to-rail output swing into heavy loads. The input common mode voltage range includes ground, and the maximum input offset voltage is 3mV for TS2173/TS2174 families. All models are specified for −40°C to +125°C.

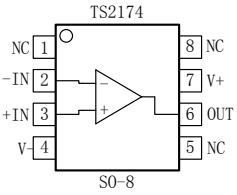
The TS2173 and TS2273 have a power-down disable feature that reduces the supply current to 1uA.

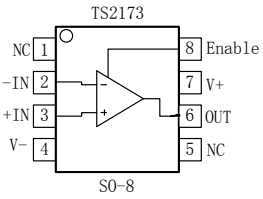
TS2174 is available inSOT-23-5 and SO-8.
TS2173 is available in SOT23-6.
TS2274 is available in SO-8.
TS2273 is available in DFN-10 and MSOP-10.
TS2474 is available in TSSOP-14and SO-14.

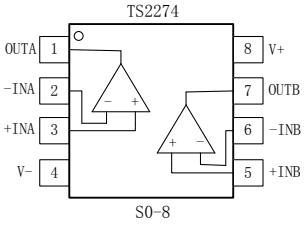


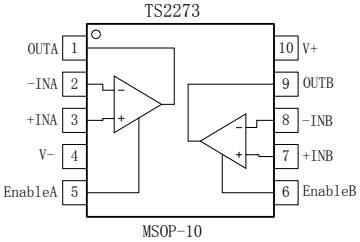


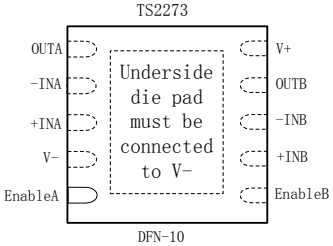












Ordering Information

Model	Status	Part Number	Eco Plan	Package	AMP	Shutdown	Container, Pack Qty
TS2174		TS2174SOT235R	Rohs	SOT23-5	1	NO	Reel,3000
TS2174		TS2174SO8R	Rohs	SO-8	1	NO	Reel,2500
TS2173		TS2173SOT236R	Rohs	SOT23-6	1	YES	Reel,3000
TS2173		TS2173SO8R	Rohs	SO-8	1	YES	Reel,2500
TS2273		TS2273MSOP10R	Rohs	MSOP-10	2	YES	Reel,2500
TS2274	ACTIVE	TS2274SO8R	Rohs	SO-8	2	NO	Reel,2500
TS2474	ACTIVE	TS2474SO14R	Rohs	SO-14	4	NO	Reel,2500
TS2474	ACTIVE	TS2474TSSOP14R	Rohs	TSSOP-14	4	NO	Reel,2500
TS2273		TS2273DFN10R	Rohs	DFN-10	2	YES	Reel,2500

Absolute Maximum Ratings

Parameter	Min	Max	Unit
Supply Voltage		7	V
Signal Input Terminal voltage	(V-)-0.5	(V+)+0.5	V
Operating Temperature	-55	155	°C
Junction Temperature		150	°C
Storage Temperature Range	-65	150	°C
Lead Temperature (Soldering, 10s)		260	°C

ESD CAUTION

ESD (electrostatic discharge) sensitive device Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjects to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

Electrical Characteristics: V_S = +2.7V to +5.5V

Boldface limits apply over the specified temperature range, **T_A = −40°C to +125°C.**
At T_A = +25°C, R_L = 10kΩ connected to V_S/2, and V_{OUT} = V_S/2, unless otherwise noted.

Symbol	Parameter	Operating Conditions	Min	Typ	Max	Unit
V_S	Power Supply Voltage		2.7		5.5	V
$V_{IN+/-}$	Input Voltage Range		(V-)-0.5		(V+)+0.5	V
I_S	Supply Current	I_O		670	800	µA
PSRR	Power Supply Rejection Ratio	V_S =2.7 to V_S =5.5V, V_{CM}<(V+) - 2V	82	94		dB
	T_A = −40°C to +125°C				**180**	**µV/V**
Input Characteristics						
V_{OS}	Input Offset Voltage			0.5	3	mV
dV_{OS}/dT	**Average Drift**	V_S=5.5V		**3**		**µV/℃**
I_B	Input Bias Current			±0.5	10	pA
I_{OS}	Input Offset Current			±0.5	10	pA
CMRR	Common Mode Rejection Ratio	(V-)-0.2V< V_{CM}<(V+)-2V	80	94		dB
	TA = −40°C to +125°C	**(V-)-0.2V< V_{CM}<(V+)-2V**	**80**			**dB**
		V_S = 5.5V, (V−) − 0.2V < V_{CM}< (V+) + 0.2V	66	80		dB
	TA = −40°C to +125°C	**V_S = 5.5V, (V−) − 0.2V < V_{CM}< (V+) + 0.2V**	**68**			**dB**
AOL	Open-Loop Gain	Vs=5.5V RL=5KΩ	100	114		dB
	TA = −40°C to +125°C		**96**			**dB**
	Open-Loop Gain	Vs=5.5V RL=100kΩ	102	114		dB
	TA = −40°C to +125°C		**100**			**dB**
Output Characteristics						
V_{OUT}	Output Voltage Swing From Rail	R_L=100KΩ		18	25	mV
	TA = −40°C to +125°C	**R_L=100KΩ**			**25**	**mV**
	Output Voltage Swing From Rail	R_L=5KΩ		75	100	mV
	TA = −40°C to +125°C	**R_L=5KΩ**			**100**	**mV**
I_{OUT}	Output Current	See typical characteristics				Ω
R_{OUT}	Closed-Loop Output Impedance	f = 200kHz, G = 1		3.5		
Dynamic Performance						
GBW	Gain Bandwidth Product			6.5		MHz
t_S	Settling Time to 0.1%	V_{OUT}=2V step; G=+1		1		µs
	Settling Time to 0.01%	V_{OUT}=2V step; G=+1		1.5		µs
	Overload recovery time	Vin*Gain>V_S		0.3		µs
SR	Slew Rate	G= +1		5		V/µs
THD	Total Harmonic Distortion+ Noise	V_S=5V, Vo=3Vpp,G= +1, f=1kHz		0.0013		%

Electrical Characteristics: V_S = +2.7V to +5.5V

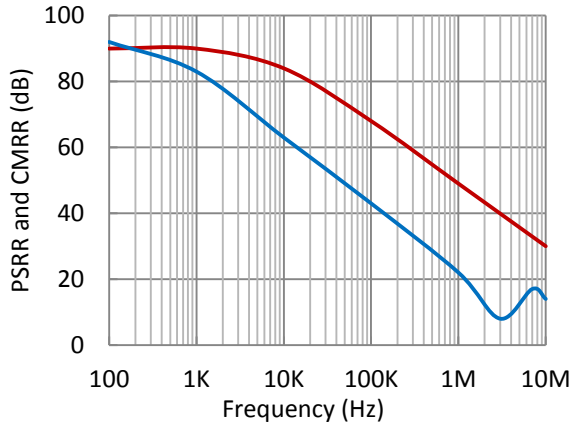
Boldface limits apply over the specified temperature range, **T_A = −40°C to +125°C.**
At T_A = +25°C, RL = 10kΩ connected to V_S/2, and V_{OUT} = V_S/2, unless otherwise noted.

Symbol	Parameter	Operating Conditions	Min	Type	Max	Unit
Noise Performance						
V_{noise}	Input Voltage Noise	f=0.1Hz to 10Hz		10		μVpp
e_n	Input Voltage Noise Density	f=10kHz		15		nV/$\sqrt{\text{Hz}}$
i_n	Input Current Noise Density	f=10kHz		4		fA/$\sqrt{\text{Hz}}$
Temperature Range						
	Specified Range		−40		+125	°C
	OperatingRange		−55		+150	°C
	Storage Range		−65		+150	°C
θ_{JA}	Thermal Resistance					
	SOT23-5,SOT23-6,SOT23-8			200		°C/W
	MSOP-10,SO-8			150		°C/W
	SO-14, TSSOP-14			100		°C/W
	DFN-10			56		°C/W

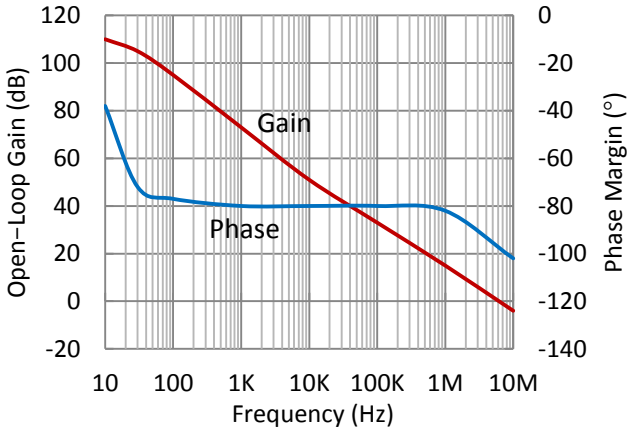
Typical Characteristics

At T_A = +25°C, R_L = 10kΩ connected to V_S/2, and V_{OUT} = V_S/2, unless otherwise noted.

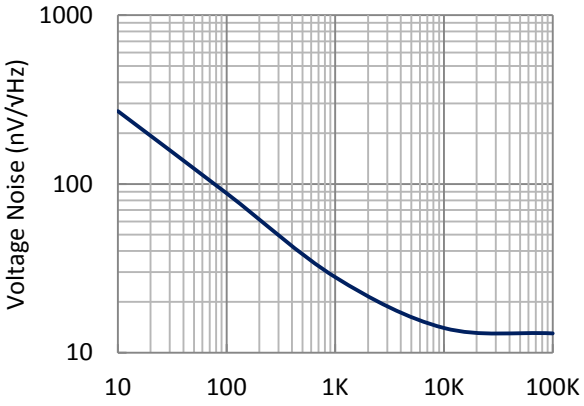
POWER−SUPPLY AND COMMON−MODE REJECTION RATIO vs FREQUENCY



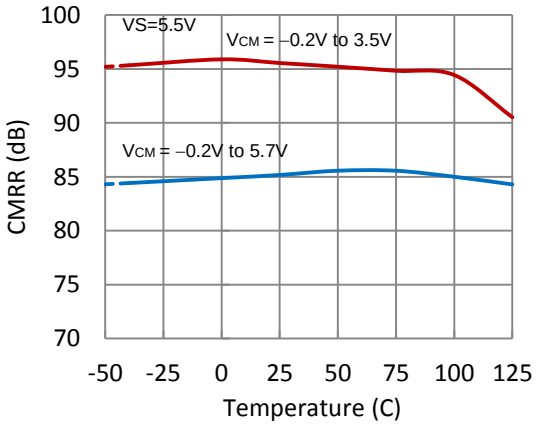
OPEN−LOOP GAIN AND PHASE vs FREQUENCY



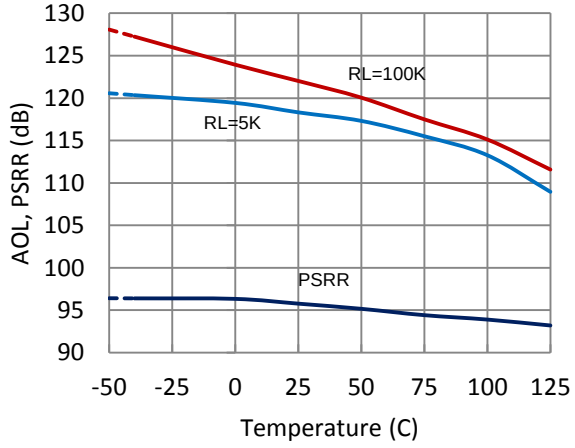
INPUT VOLTAGE NOISE SPECTRAL DENSITY vs FREQUENCY



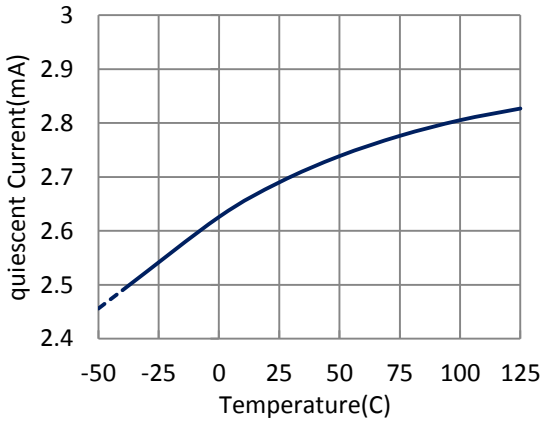
COMMON−MODE REJECTION RATIO vs TEMPERATURE



OPEN−LOOP GAIN AND POWER−SUPPLY REJECTION RATIO vs TEMPERATURE



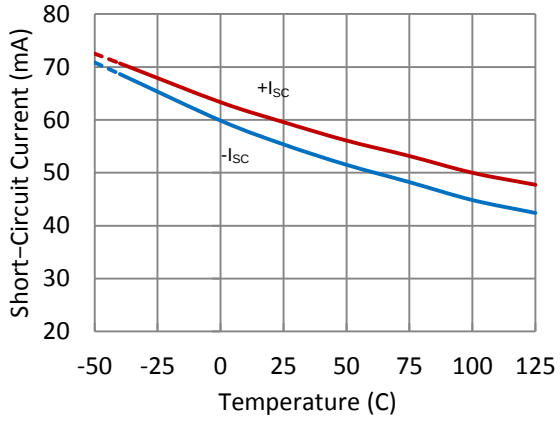
QUIESCENT CURRENT vs TEMPERATURE



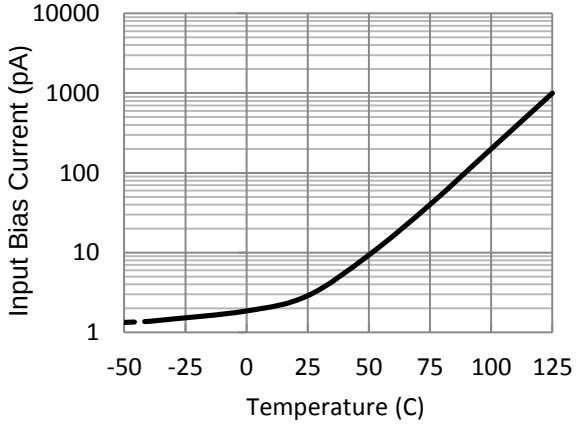
Typical Characteristics

At T_A = +25°C, R_L = 10kΩ connected to V_S/2, and V_{OUT} = V_S/2, unless otherwise noted.

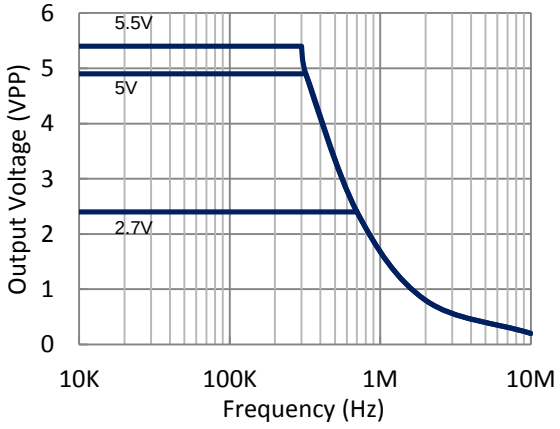
SHORT−CIRCUIT CURRENT vs TEMPERATURE



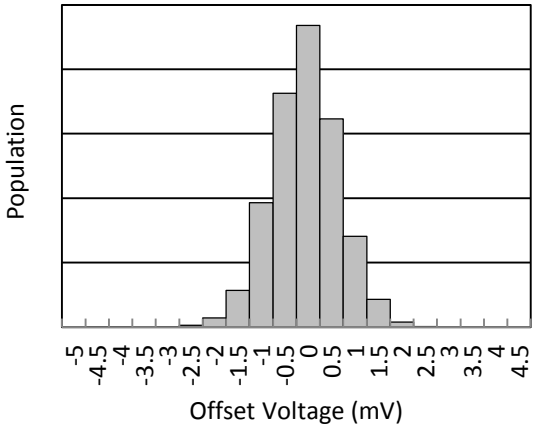
INPUT BIAS CURRENT vs TEMPERATURE



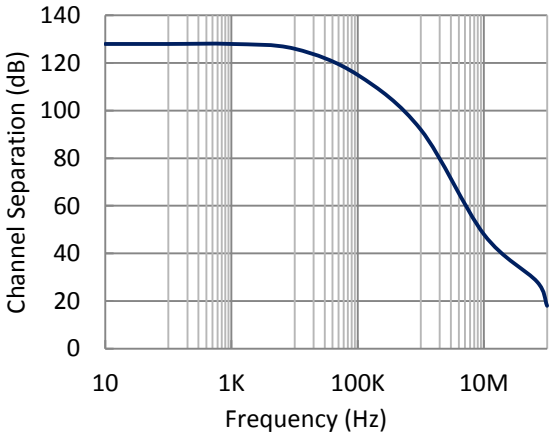
MAXIMUM OUTPUT VOLTAGE vs FREQUENCY



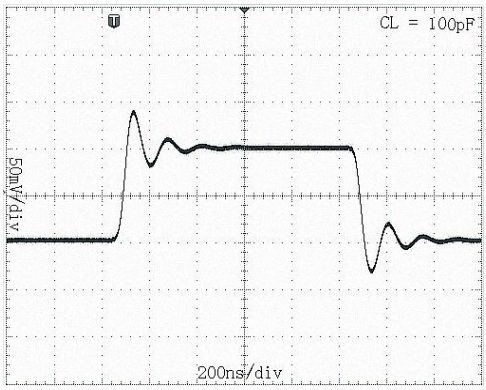
OFFSET VOLTAGE PRODUCTION DISTRIBUTION



CHANNEL SEPARATION vs FREQUENCY



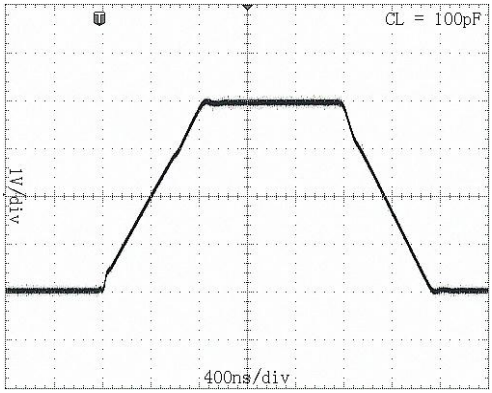
SMALL−SIGNAL STEP RESPONSE



Typical Characteristics

At T_A = +25°C, R_L = 10kΩ connected to V_S/2, and V_{OUT} = V_S/2, unless otherwise noted.

LARGE−SIGNAL STEP RESPONSE



Application Notes

The TS2173 and TS2174 families op amps are suitable for a wide range of general-purpose applications. They provide Rail-to-rail input and output. Excellent ac performance makes them well-suited for audio and sensor applications.

The input common-mode voltage range includes both rails, allowing the TS2173 and TS2174families op amps to be used in bipolar and unipolar application.

Rail-to-rail input and output swing significantly increases dynamic range, especially in low-supply applications.

Power-supply pins should be bypassed with 0.1μF ceramic capacitors.

Power-Supply

The TS2173 and TS2174 families operate 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 +VS with a 0.1μF capacitor which should be placed close to the +VS pin. For dual-supply operation, both the +VS and the -VS supplies should be bypassed to ground with separate 0.1μF ceramic capacitors. 2.2μFtantalum capacitor can be added for better performance.

The TS2173 and TS2174 families are ideal for battery-powered instrumentation and handheld devices because it can operate at the end of discharge voltage of most popular batteries.

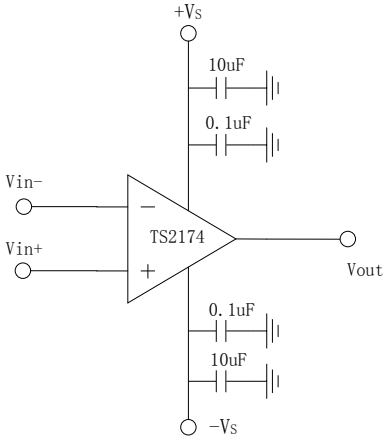


Figure1.Amplifier with Bypass Capacitors

Driving Capacitive Loads

The TS2173 and TS2174families 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 result in ringing or even oscillation. Applications that require greater capacitive driving capability should use an isolation resistor between the output and the capacitive load like the circuit in Figure2. The isolation resistor R_{ISO} and the load capacitor CL 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}.

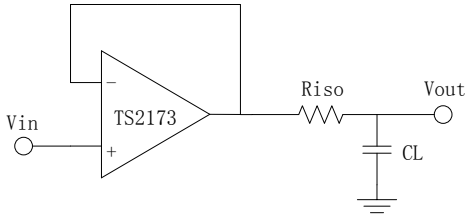


Figure2.Indirectly Driving Heavy Capacitive Load

An improved circuit is shown in Figure 3. It provides DC accuracy as well as AC stability. Rf provides the DC accuracy by connecting the inverting signal with the output. Cf 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.

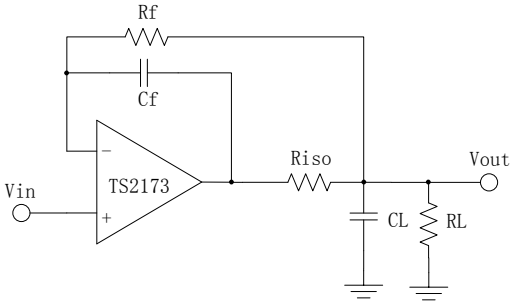


Figure 3. Indirectly Driving Heavy Capacitive Load with DC Accuracy

For non-buffer configuration, there are two other 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.

Typical Application

Difference Amplifier

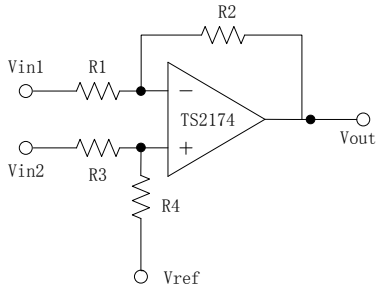


Figure4

Differential Amplifier

The circuit shown in Figure 4 performs the difference function. If the resistor ratios are equal (R4/R3 = R2/R1) then Vout= (Vin2 – Vin1) × R2/R1 + Vref.

Instrumentation Amplifier

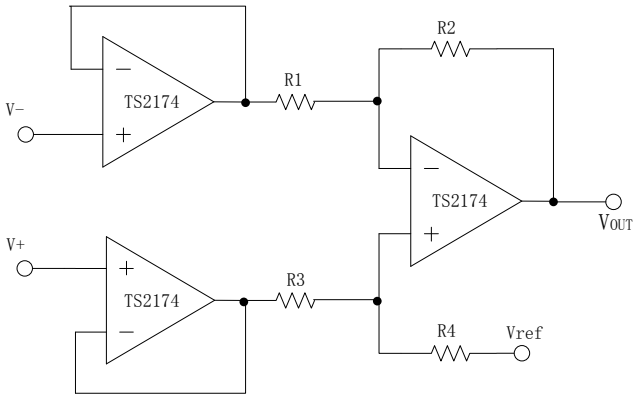


Figure6

Instrumentation Amplifier

The circuit in Figure 6 performs the same function as that in Figure 4 but with the high input impedance.

Low Pass Active Filter

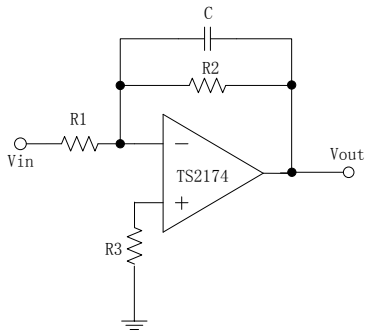


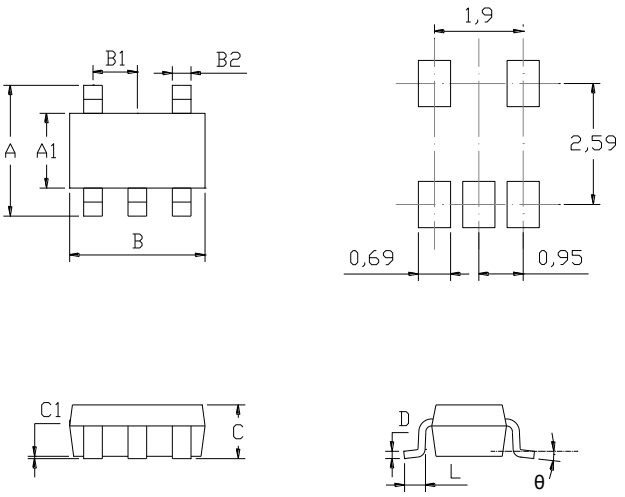
Figure5

Low Pass Active Filter

The low pass filter shown in Figure 5 has a DC gain of (-R2 / R1) and the –3dB corner frequency is 1/2πR2C. Make sure the filter 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.

Mechanical Dimensions

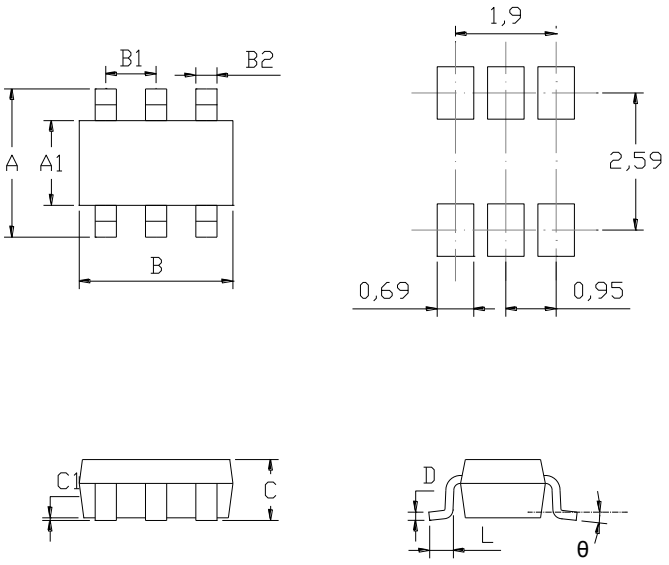
SOT23-5 package mechanical drawing



SOT23-5 package mechanical data

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	2.6	3	0.1024	0.1181
A1	1.45	1.75	0.0571	0.0689
B	2.75	3.05	0.1083	0.1201
B1	0.95		0.0374	
B2	0.3	0.5	0.0118	0.0197
C		1.45MAX		0.0571MAX
C1	0	0.15	0.0000	0.0059
L	0.3	0.5	0.0118	0.0197
D	0.08	0.22	0.0031	0.0087
θ	0°	8°	0°	8°

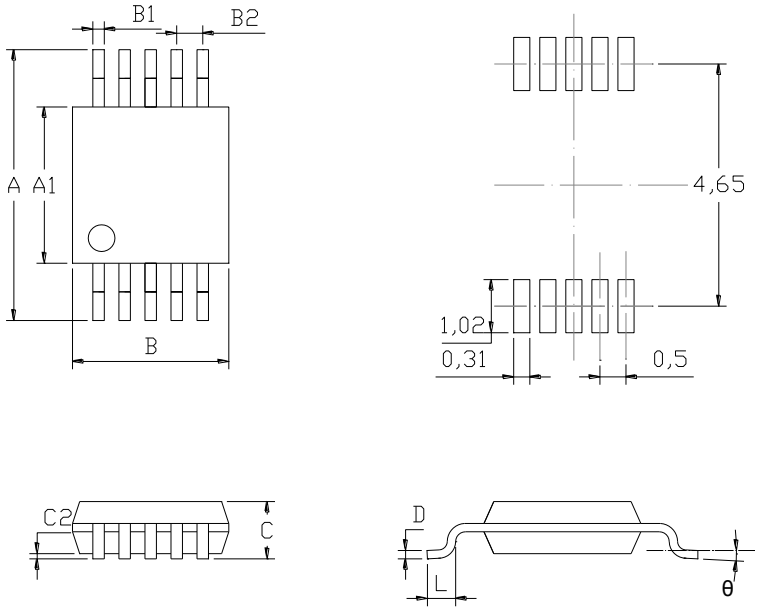
SOT23-6 package mechanical drawing



SOT23-6 package mechanical data

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	2.6	3	0.1024	0.1181
A1	1.45	1.75	0.0571	0.0689
B	2.75	3.05	0.1083	0.1201
B1	0.95		0.0374	
B2	0.3	0.5	0.0118	0.0197
C		1.45MAX		0.0571 MAX
C1	0	0.15	0.0000	0.0059
L	0.3	0.5	0.0118	0.0197
D	0.08	0.22	0.0031	0.0087
θ	0^o	8^o	0^o	8^o

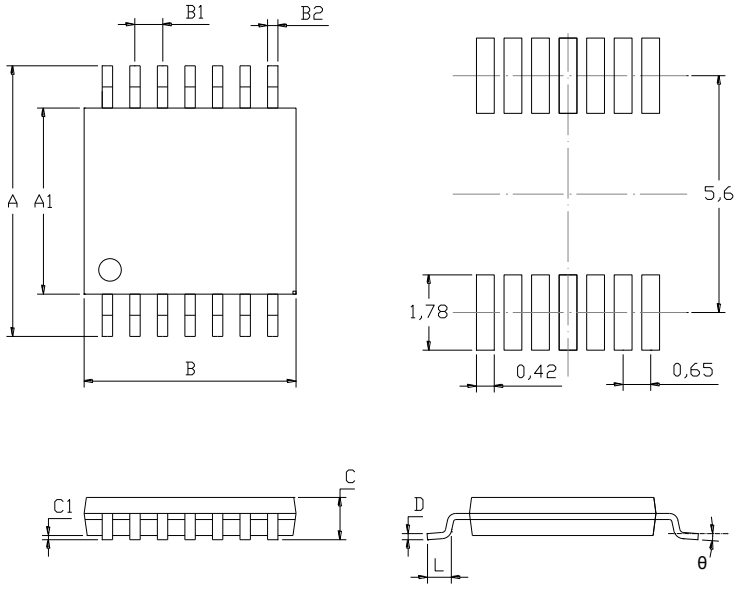
MSOP-10 package mechanical drawing



MSOP-10 package mechanical data

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	4.75	5.05	0.1870	0.1988
A1	2.9	3.1	0.1142	0.1220
B	2.9	3.1	0.1142	0.1220
B1	0.50		0.0197	
B2	0.17	0.27	0.0067	0.0106
C		1.10MAX		0.0433
C1	0.05	0.15	0.0020	0.0059
L	0.4	0.7	0.0157	0.0276
D	0.13	0.23	0.0051	0.0091
θ	0^o	8^o	0^o	8^o

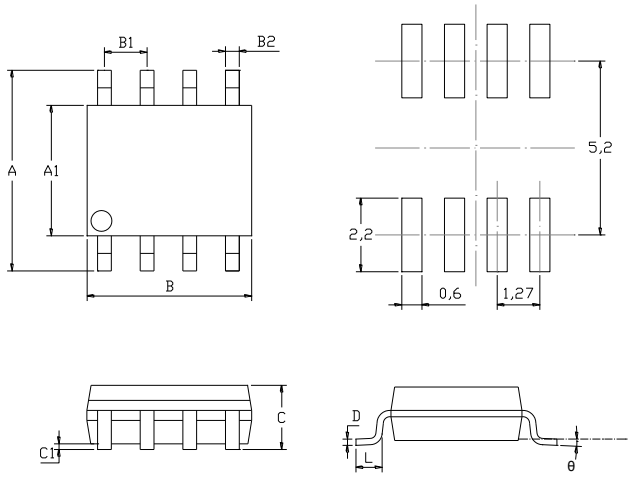
TSSOP-14 package mechanical drawing



TSSOP-14 package mechanical data

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	6.2	6.6	0.2441	0.2598
A1	4.3	4.5	0.1693	0.1772
B	4.9	5.1	0.1929	0.2008
B1	0.65		0.0256	
B2	0.19	0.3	0.0075	0.0118
C		1.20MAX		0.0472MAX
C1	0.05	0.15	0.0020	0.0059
L	0.5	0.75	0.0197	0.0295
D	0.1	0.2	0.0039	0.0079
θ	0^o	8^o	0^o	8^o

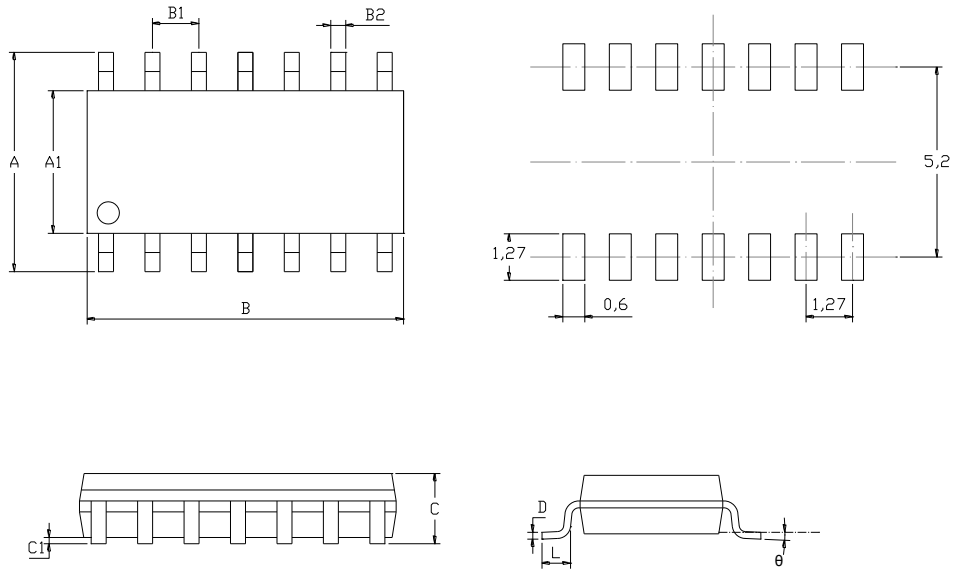
SO-8 package mechanical drawing



SO-8 package mechanical data

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	5.8	6.2	0.2283	0.2441
A1	3.8	4	0.1496	0.1575
B	4.8	5	0.1890	0.1969
B1	1.27		0.0500	
B2	0.31	0.51	0.0122	0.0201
C		1.75MAX		0.0689MAX
C1	0.1	0.25	0.0039	0.0098
L	0.4	1.27	0.0157	0.0500
D	0.13	0.25	0.0051	0.0098
θ	0^o	8^o	0^o	8^o

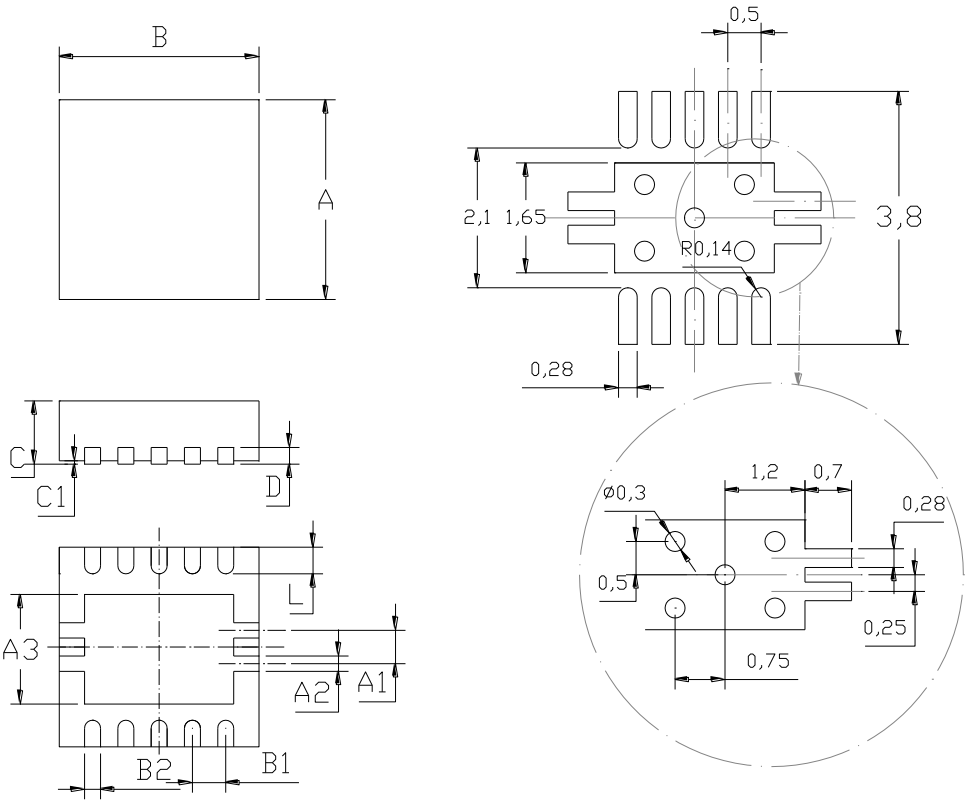
SO-14 package mechanical drawing



SO-14 package mechanical data

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	6.2	5.8	0.2441	0.2283
A1	3.8	4	0.1496	0.1575
B	8.55	8.75	0.3366	0.3445
B1	1.27		0.0500	
B2	0.31	0.51	0.0122	0.0201
C		1.75MAX		0.0689
C1	0.1	0.25	0.0039	0.0098
L	0.4	1.27	0.0157	0.0500
D	0.13	0.25	0.0051	0.0098
θ	0^o	8^o	0^o	8^o

DFN-10 package mechanical drawing



DFN-10 package mechanical data

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	2.9	3.1	0.1142	0.1220
A1	0.5		0.0197	
A2	0.23		0.0091	
A3	1.55	1.75	0.0610	0.0689
B	2.9	3.1	0.1142	0.1220
B1	0.5		0.0197	
B2	0.18	0.3	0.0071	0.0118
C	0.8	1	0.0315	0.0394
C1	0	0.05	0.0000	0.0020
L	0.3	0.5	0.0118	0.0197
D	0.2		0.0079	

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Document RAV. KNY.2.01A