

### Features

- Gain-bandwidth Product: 20MHz
- Offset Voltage: 50  $\mu$ V (max)
- Low Noise: 7.3nV/ $\sqrt{\text{Hz}}$ (f= 1kHz)
- Slew Rate: 25 V/ $\mu$ s
- Low THD+N: 0.0005%
- Supply Range: 2.2V to 5.5V
- Supply Current: 3.5 mA/ch
- Low Input Bias Current: 0.3pA Typical
- Rail-to-Rail I/O
- High Output Current: 70mA (1.0V Drop)
- -40°C to 125°C Operation Range

### Applications

- Sensor Signal Conditioning
- Consumer Audio
- Multi-Pole Active Filters
- Control-Loop Amplifiers
- Communications
- Security
- Scanners

### Description

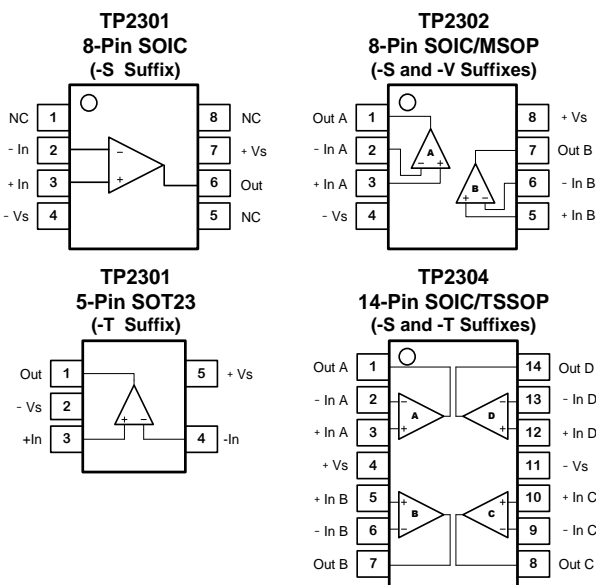
The TP2301 series products are very high precision amplifiers featuring very low noise, low offset voltage, high bandwidth, low input bias current and low temperature drift making them the ideal choice for applications requiring both high DC accuracy and AC performance. The combination of precision, low noise, and high bandwidth provides the user with outstanding value and flexibility relative to similar competitive parts.

Applications for these amplifiers include precision active filters, medical and analytical instrumentation, precision power supply controls, and industrial controls requiring high gains. Featuring low THD+N, the TP2301 series is also excellent for consumer audio applications, particularly for single-supply systems.

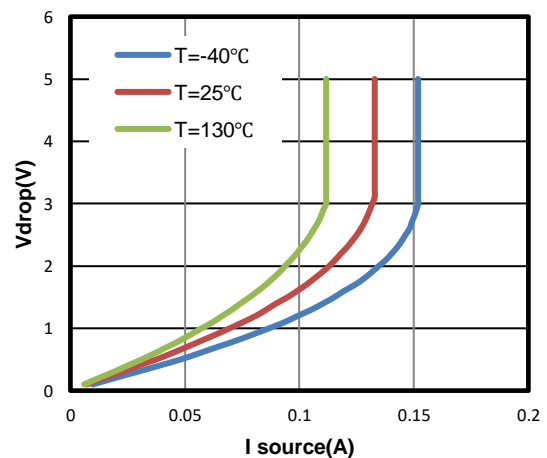
The TP2301 is single channel version available in 8-pin SOIC and 5-pin SOT23 packages. The TP2302 is dual channel version available in 8-pin SOIC and MSOP packages. The TP2304 is quad channel version available in 14-pin SOP and TSSOP packages.

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### Pin Configuration (Top View)



Positive Output Swing vs. Load Current



# TP2301 / TP2302 / TP2304

## 20MHz Bandwidth, Low Noise High Precision Op-amps

### Order Information

Order Number	Package	MSL	Transport Media, Quantity	Marking Information
TP2301-TR	5-Pin SOT23	MSL3	Tape and Reel, 3,000	301
TP2302-SR	8-Pin SOIC	MSL3	Tape and Reel, 4,000	TP2302
TP2302-VR	8-Pin MSOP	MSL3	Tape and Reel, 3,000	TP2302
TP2304-SR <sup>Note 1</sup>	14-Pin SOIC	MSL3	Tape and Reel, 2,500	TP2304
TP2304-TR	14-Pin TSSOP	MSL3	Tape and Reel, 3,000	TP2304

Note 1: Future product, contact 3PEAK factory for more information and sample.

### Absolute Maximum Ratings <sup>Note 1</sup>

Supply Voltage:  $V^+ - V^-$  <sup>Note 2</sup> ..... 7.0V  
 Voltage on Input Pin .....  $V^- - 0.3$  to  $V^+ + 0.3$   
 Voltage on Output Pin .....  $V^- - 0.3$  to  $V^+ + 0.3$   
 Differential Input Voltage .....  $V^- - V^+$  to  $V^+ - V^-$   
 Input Current: +IN, -IN <sup>Note 3</sup> .....  $\pm 20$ mA

Output Short-Circuit Duration <sup>Note 4</sup> ..... Infinite  
 Operating Temperature Range .....  $-40^\circ\text{C}$  to  $125^\circ\text{C}$   
 Maximum Junction Temperature .....  $150^\circ\text{C}$   
 Storage Temperature Range .....  $-65^\circ\text{C}$  to  $150^\circ\text{C}$   
 Lead Temperature (Soldering, 10 sec) .....  $260^\circ\text{C}$

**Note 1:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

**Note 2:** The op amp supplies must be established simultaneously, with, or before, the application of any input signals.

**Note 3:** The inputs are protected by ESD protection diodes to each power supply. If the input extends more than 500mV beyond the power supply, the input current should be limited to less than 10mA.

**Note 4:** A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

### ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001	4	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002	1.5	kV

### Thermal Resistance

Package Type	$\theta_{JA}$	$\theta_{JC}$	Unit
5-Pin SOT23	250	81	$^\circ\text{C}/\text{W}$
8-Pin SOIC	158	43	$^\circ\text{C}/\text{W}$
8-Pin MSOP	210	45	$^\circ\text{C}/\text{W}$
14-Pin SOIC	120	36	$^\circ\text{C}/\text{W}$
14-Pin TSSOP	180	35	$^\circ\text{C}/\text{W}$

20MHz Bandwidth, Low Noise High Precision Op-amps

**Electrical Characteristics**

The specifications are at  $T_A = 27^\circ\text{C}$ .  $V_S = +2.2\text{ V to }+5.5\text{ V}$ , or  $\pm 1.1\text{ V to } \pm 2.75\text{ V}$ ,  $R_L = 2\text{k}\Omega$ ,  $C_L = 100\text{pF}$ . Unless otherwise noted.

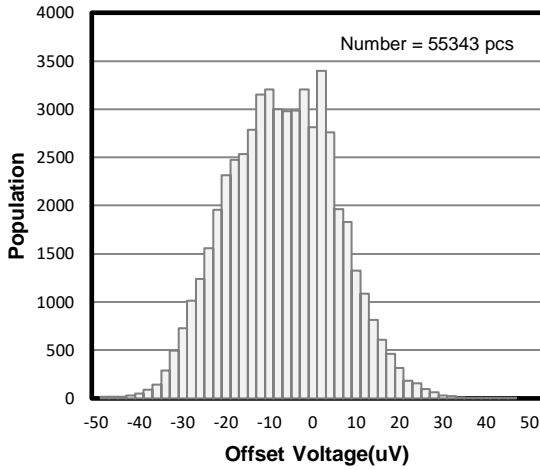
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V <sub>OS</sub>	Input Offset Voltage	V <sub>CM</sub> = V <sub>DD</sub> /2, TP2301 and TP2302	-50	±7	+50	μV
		V <sub>CM</sub> = V <sub>DD</sub> /2, TP2304	-100	±15	+100	μV
V <sub>OS</sub> TC	Input Offset Voltage Drift	-40°C to 125°C		1	2	μV/°C
I <sub>B</sub>	Input Bias Current	T <sub>A</sub> = 27 °C		0.3		pA
		T <sub>A</sub> = 85 °C		150		pA
		T <sub>A</sub> = 125 °C		300		pA
I <sub>OS</sub>	Input Offset Current			0.001		pA
V <sub>n</sub>	Input Voltage Noise	f = 0.1Hz to 10Hz		2.0		μV <sub>PP</sub>
e <sub>n</sub>	Input Voltage Noise Density	f = 1kHz		7.3		nV/√Hz
i <sub>n</sub>	Input Current Noise	f = 1kHz		2		fA/√Hz
R <sub>IN</sub>	Input impedance			10 <sup>12</sup>		Ω
C <sub>IN</sub>	Input Capacitance	Differential		7.76		pF
		Common Mode		6.87		
CMRR	Common Mode Rejection Ratio	V <sub>CM</sub> = 2V to 3V	80	100		dB
V <sub>CM</sub>	Common-mode Input Voltage Range		(V <sup>-</sup> ) - 0.3		(V <sup>+</sup> ) + 0.3	V
PSRR	Power Supply Rejection Ratio	V <sub>CM</sub> = 2.5V, V <sub>S</sub> = 4V to 5V	80	100		dB
A <sub>VOL</sub>	Open-Loop Large Signal Gain	R <sub>LOAD</sub> = 2kΩ	100	130		dB
V <sub>OL</sub> , V <sub>OH</sub>	Output Swing from Supply Rail	R <sub>LOAD</sub> = 2kΩ		20	50	mV
R <sub>OUT</sub>	Closed-Loop Output Impedance	G = 1, f = 1MHz, I <sub>OUT</sub> = 0		0.043		Ω
R <sub>O</sub>	Open-Loop Output Impedance	f = 1kHz, I <sub>OUT</sub> = 0		125		Ω
I <sub>SC</sub>	Output Short-Circuit Current	Sink or source current	100	130	200	mA
V <sub>DD</sub>	Supply Voltage		2.2		5.5	V
I <sub>Q</sub>	Quiescent Current per Amplifier	TP2301, V <sub>DD</sub> = 5V		5	9	mA
		TP2302/TP2304, V <sub>DD</sub> = 5V		3.5	5	mA
PM	Phase Margin	R <sub>LOAD</sub> = 1kΩ, C <sub>LOAD</sub> = 60pF		60		°
GM	Gain Margin	R <sub>LOAD</sub> = 1kΩ, C <sub>LOAD</sub> = 60pF		11		dB
GBWP	Gain-Bandwidth Product	f = 1kHz		20		MHz
SR	Slew Rate	A <sub>V</sub> = 1, V <sub>OUT</sub> = 1.5V to 3.5V, C <sub>LOAD</sub> = 60pF, R <sub>LOAD</sub> = 1kΩ	15	25		V/μs
FPBW	Full Power Bandwidth <sup>Note 1</sup>			5.21		MHz
t <sub>s</sub>	Settling Time, 0.1% Settling Time, 0.01%	A <sub>V</sub> = -1, 1V Step		0.29		μs
				0.45		
THD+N	Total Harmonic Distortion and Noise	f = 1kHz, A <sub>V</sub> = 1, R <sub>L</sub> = 2kΩ, V <sub>OUT</sub> = 1V <sub>p-p</sub>		123		dB
X <sub>talk</sub>	Channel Separation	f = 1kHz, R <sub>L</sub> = 2kΩ		110		dB

**Note 1:** Full power bandwidth is calculated from the slew rate  $FPBW = SR/\pi \cdot V_{P-P}$

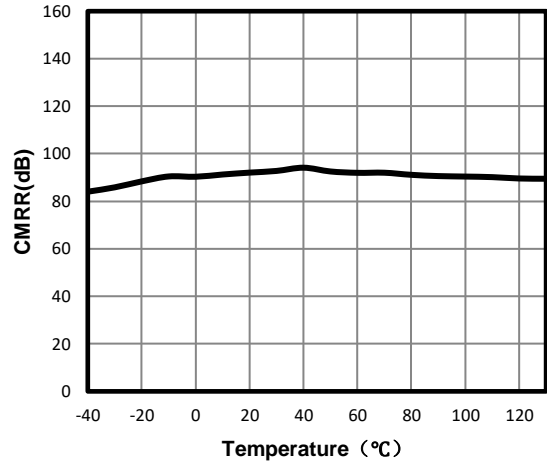
## 20MHz Bandwidth, Low Noise High Precision Op-amps Typical Performance Characteristics

$V_S = \pm 2.5V$ ,  $V_{CM} = 0V$ ,  $R_L = \text{Open}$ , unless otherwise specified.

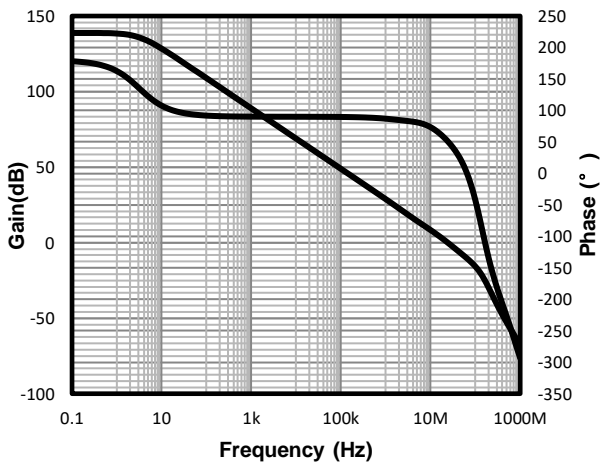
### Offset Voltage Production Distribution



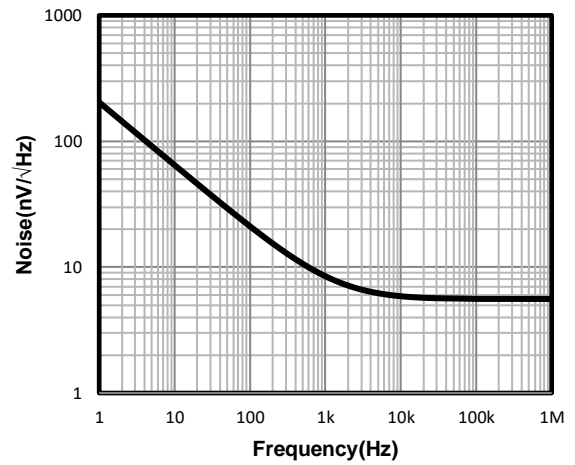
### CMRR vs. Temperature



### Open-Loop Gain and Phase



### Input Voltage Noise Spectral Density

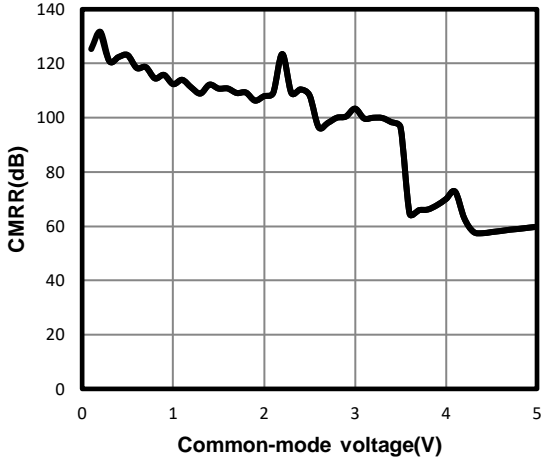


20MHz Bandwidth, Low Noise High Precision Op-amps

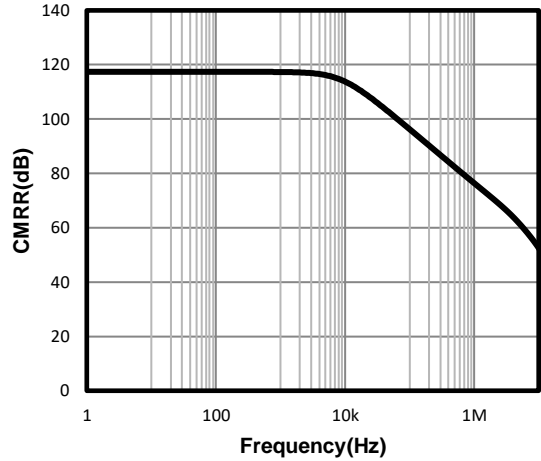
**Typical Performance Characteristics**

$V_S = \pm 2.5V$ ,  $V_{CM} = 0V$ ,  $R_L = \text{Open}$ , unless otherwise specified. (Continued)

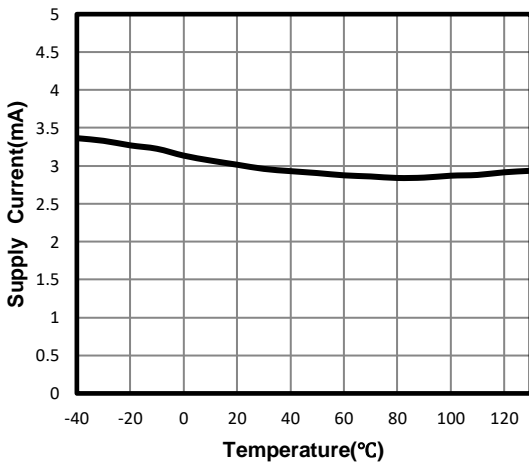
**Common Mode Rejection Ratio**



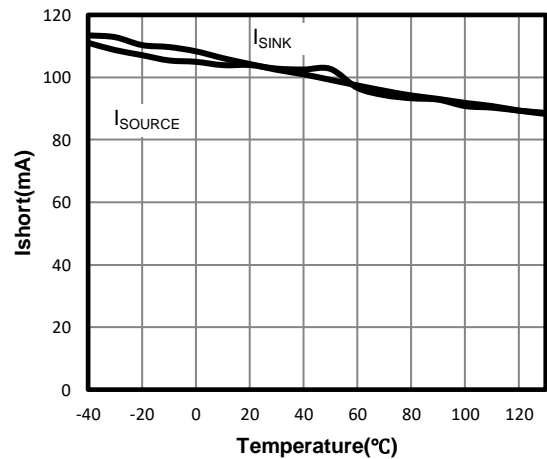
**CMRR vs. Frequency**



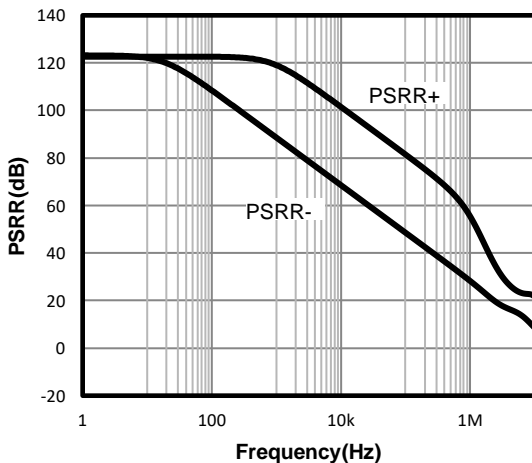
**Quiescent Current vs. Temperature**



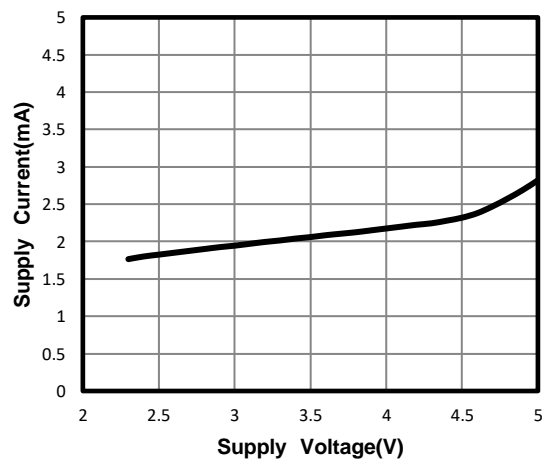
**Short Circuit Current vs. Temperature**



**Power-Supply Rejection Ratio**



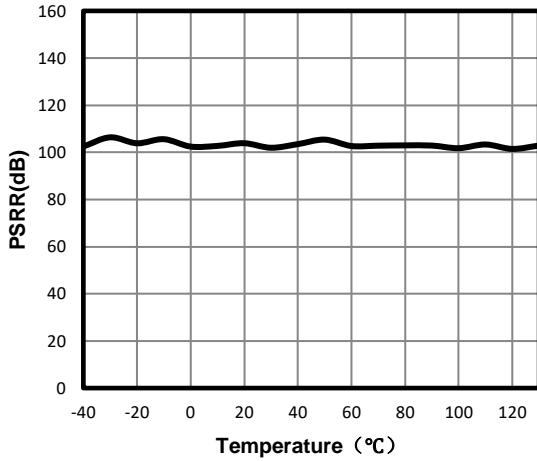
**Quiescent Current vs. Supply Voltage**



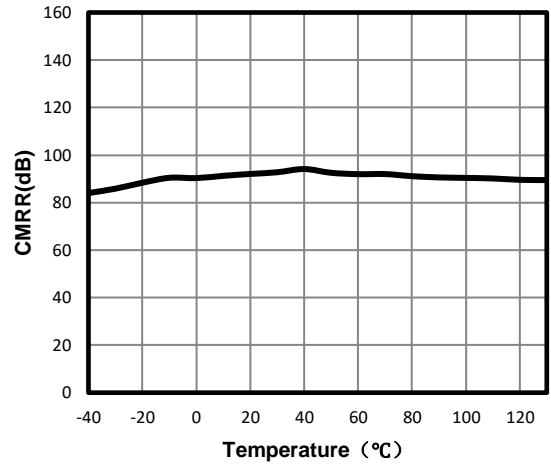
20MHz Bandwidth, Low Noise High Precision Op-amps  
**Typical Performance Characteristics**

$V_S = \pm 2.5V$ ,  $V_{CM} = 0V$ ,  $R_L = \text{Open}$ , unless otherwise specified. (Continued)

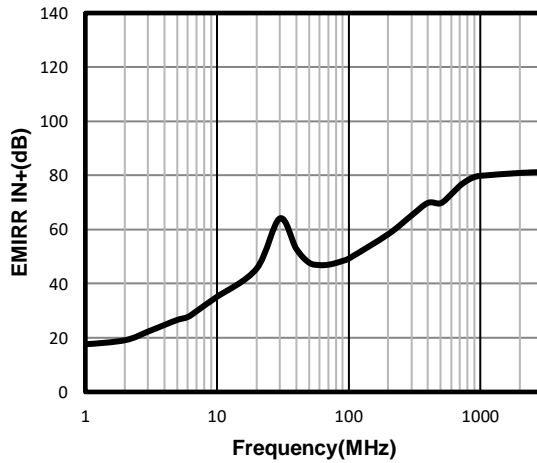
Power-Supply Rejection Ratio vs. Temperature



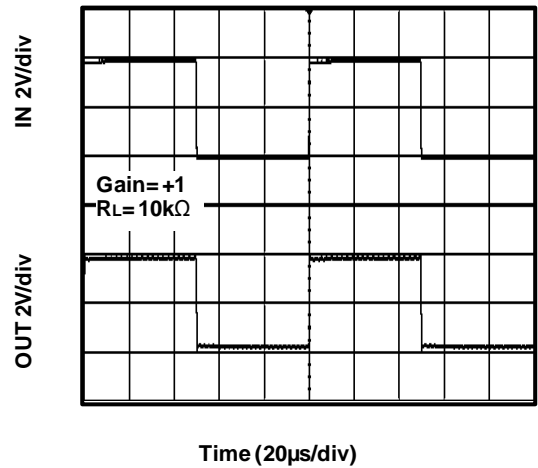
CMRR vs. Temperature



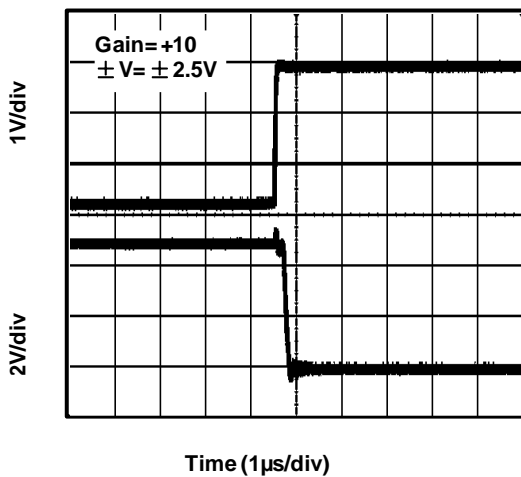
EMIRR IN+ vs. Frequency



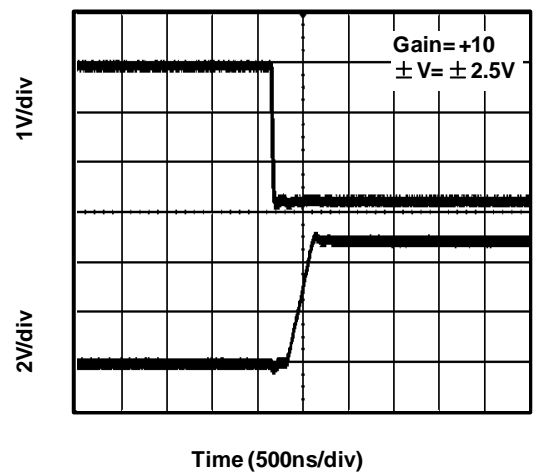
Large-Scale Step Response



Negative Over-Voltage Recovery



Positive Over-Voltage Recovery

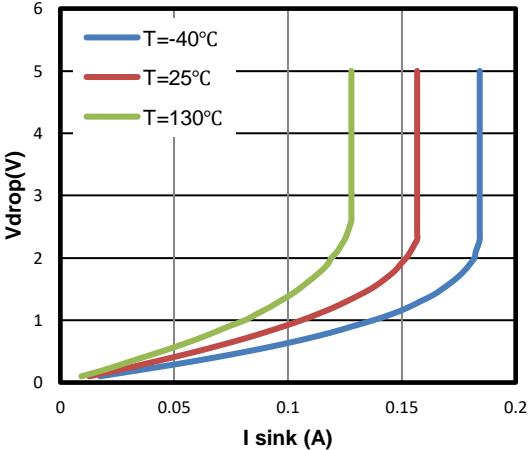


20MHz Bandwidth, Low Noise High Precision Op-amps

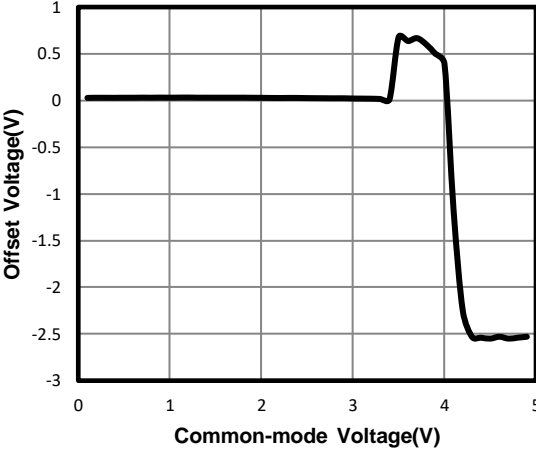
Typical Performance Characteristics

V<sub>s</sub> = ±2.5V, V<sub>CM</sub> = 0V, R<sub>L</sub> = Open, unless otherwise specified. (Continued)

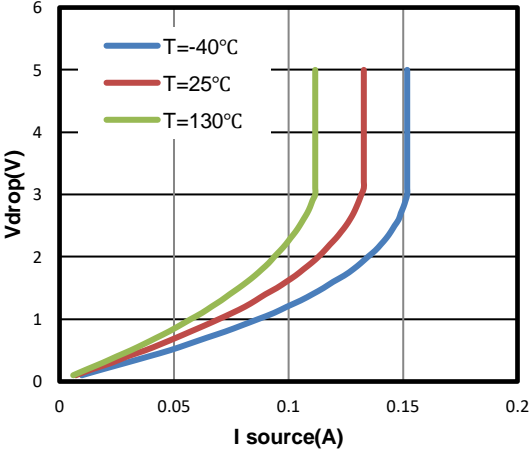
Negative Output Swing vs. Load Current



Offset Voltage vs Common-Mode Voltage



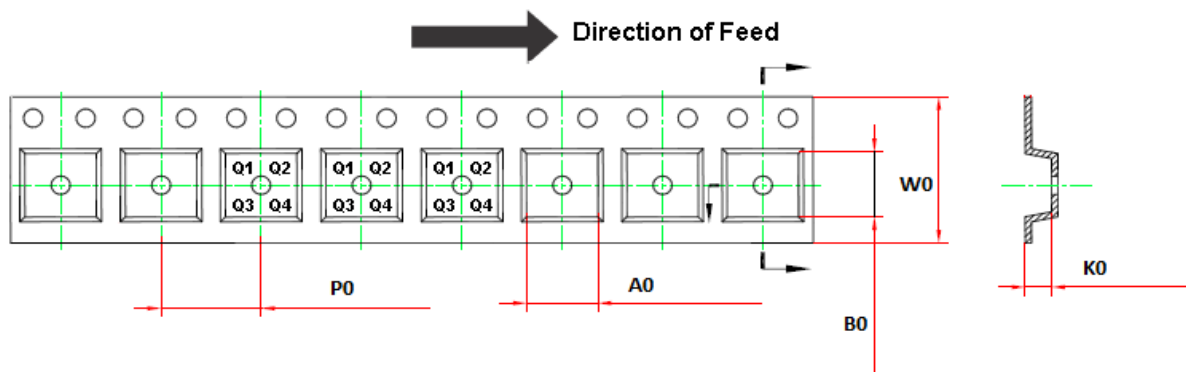
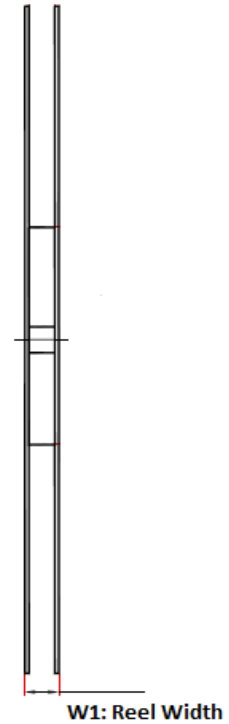
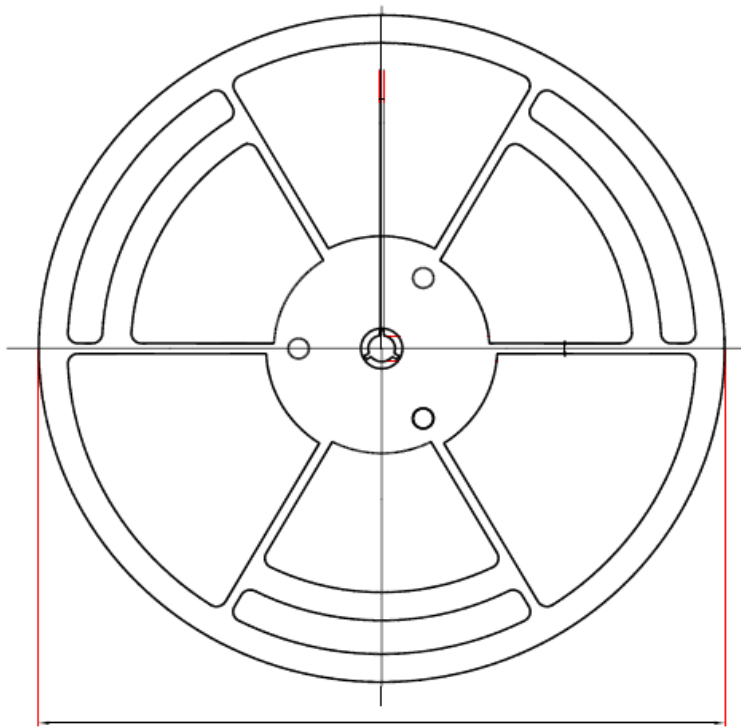
Positive Output Swing vs. Load Current



# TP2301 / TP2302 / TP2304

## 20MHz Bandwidth, Low Noise High Precision Op-amps

### Tape and Reel Information



Order Number	Package	D1	W1	A0	B0	K0	P0	W0	Pin1 Quadrant
TP2301-TR	SOT23-5	179.0	12.0	3.3	3.25	1.4	4.0	8.0	Q3
TP2302-SR	SOP8	330.0	17.6	6.5	5.4	2.0	8.0	12.0	Q1
TP2302-VR	MSOP8	330.0	17.6	5.2	3.3	1.5	8.0	12.0	Q1
TP2304-SR	SOP14	330.0	21.6	6.5	9.1	1.9	8.0	16.0	Q1
TP2304-TR	TSSOP14	330.0	17.6	6.8	5.5	1.7	8.0	12.0	Q1

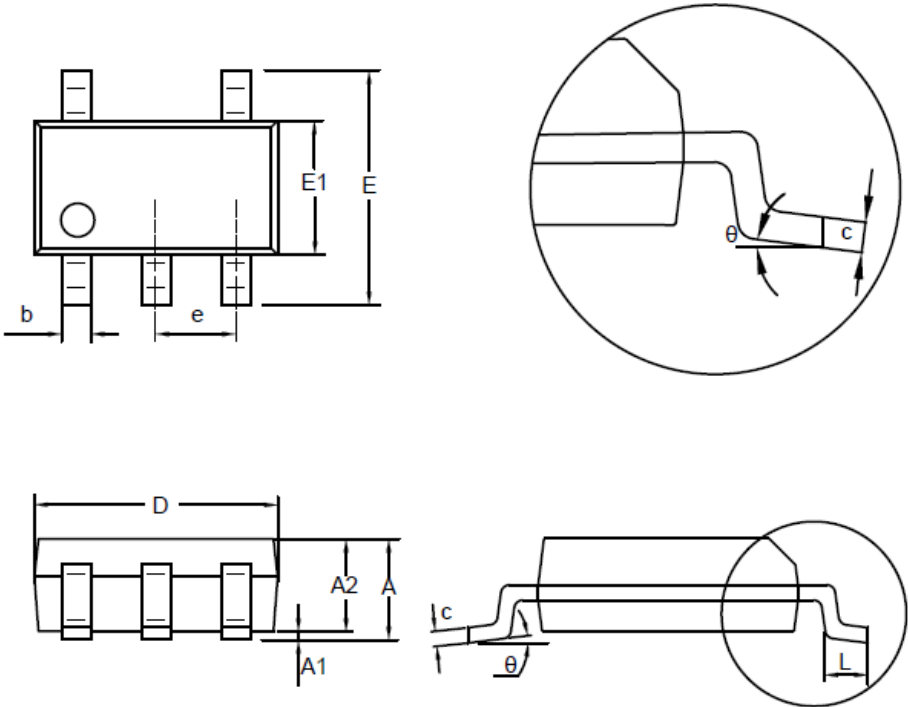


Package Outline Dimensions

SOT23-5

Package Outline Dimensions

S5T(SOT23-5-A)



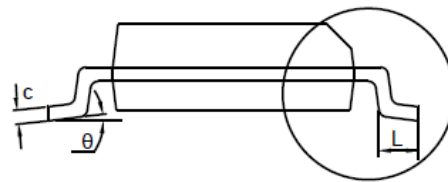
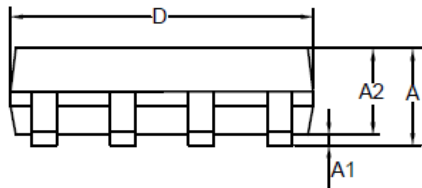
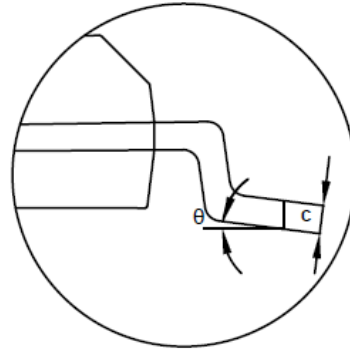
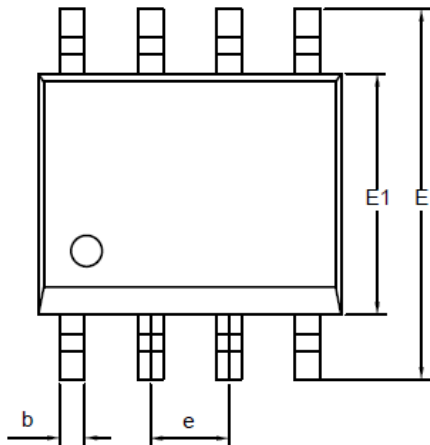
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.280	0.500	0.011	0.020
c	0.100	0.230	0.004	0.009
D	2.820	3.020	0.111	0.119
E	2.600	3.000	0.102	0.118
E1	1.500	1.720	0.059	0.068
e	0.950 BSC		0.037 BSC	
L	0.300	0.600	0.012	0.024
theta	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

Package Outline Dimensions

SO1(SOP-8-A)

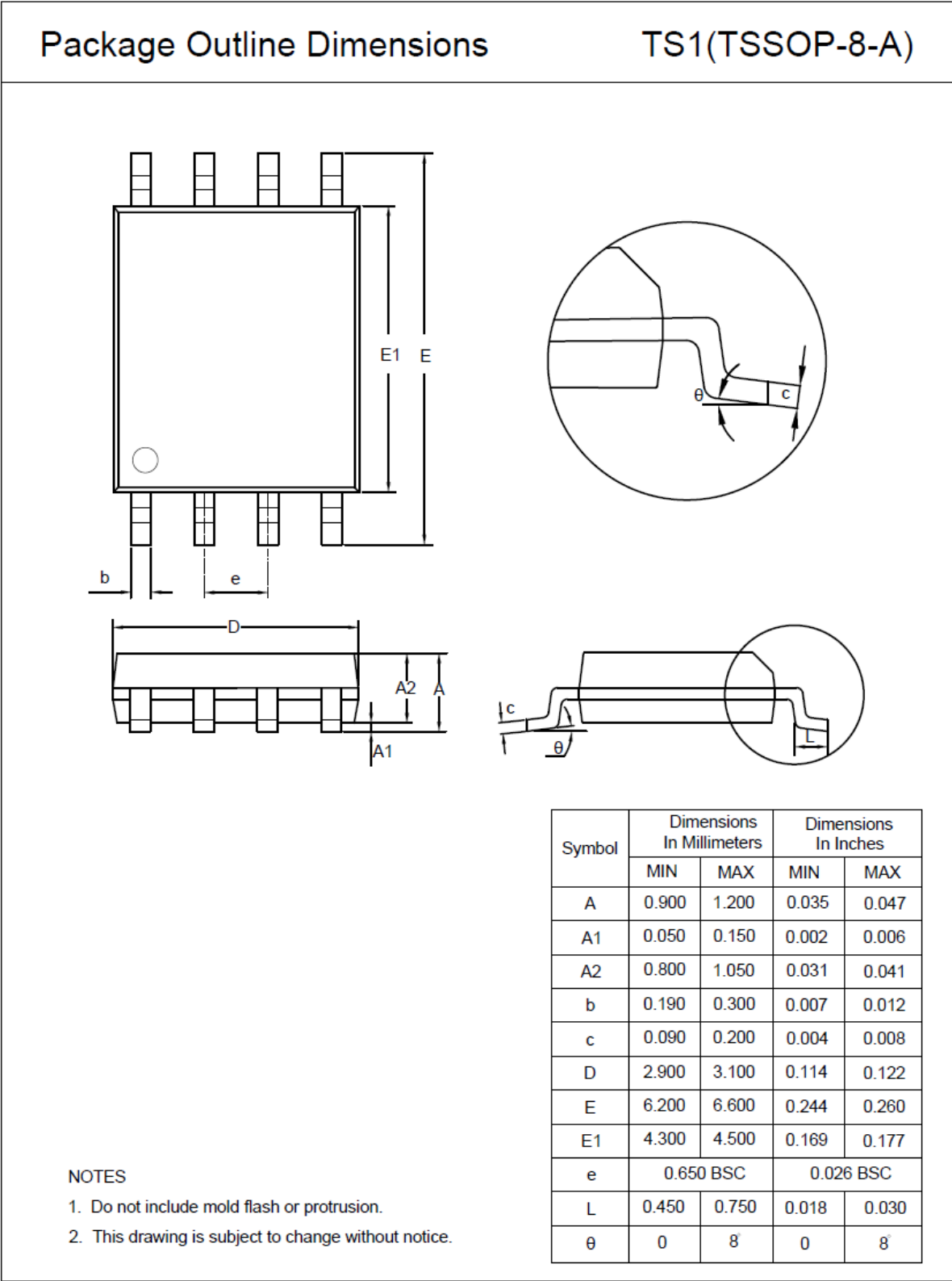


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 BSC	
L	0.400	1.000	0.016	0.039
theta	0	8	0	8

NOTES

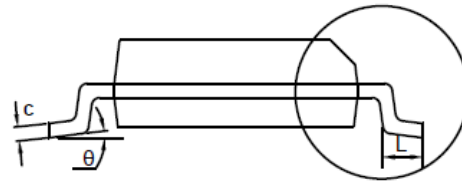
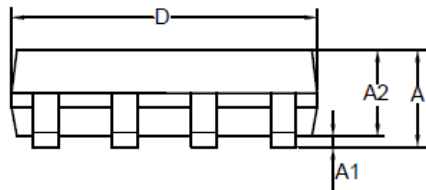
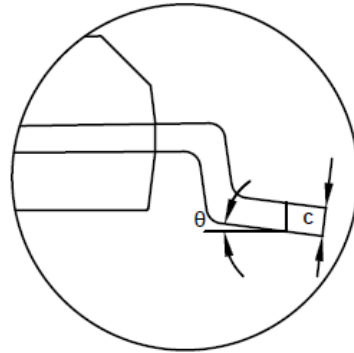
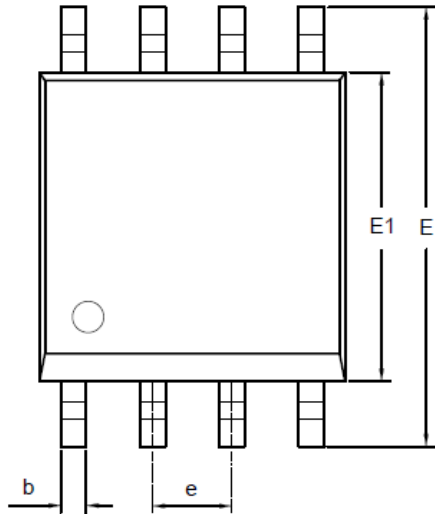
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

TSSOP8



Package Outline Dimensions

VS1(MSOP-8-A)

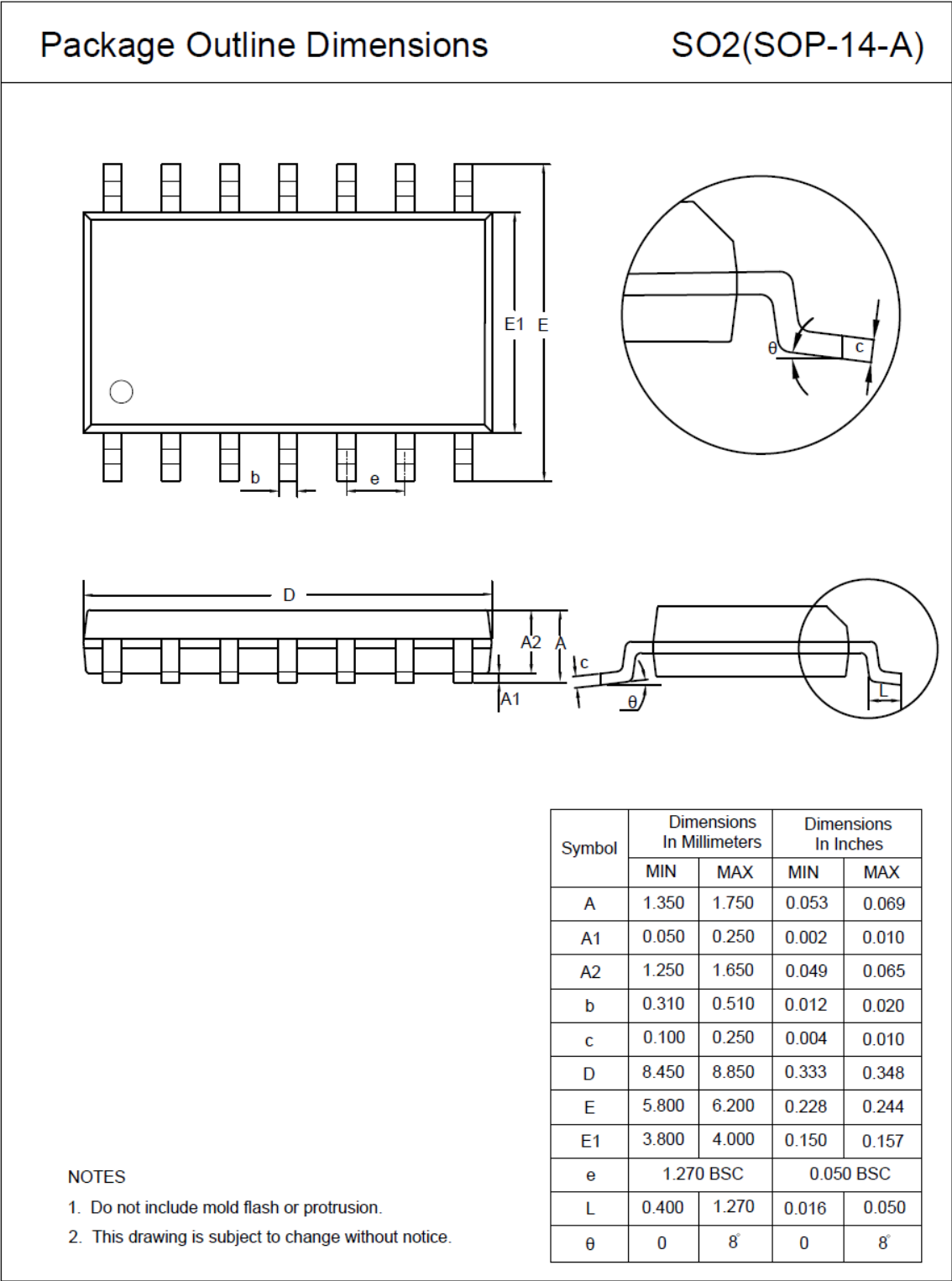


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.050	0.150	0.002	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.650 BSC		0.026 BSC	
L	0.400	0.800	0.016	0.031
$\theta$	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

SOP14



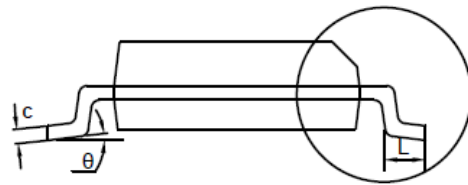
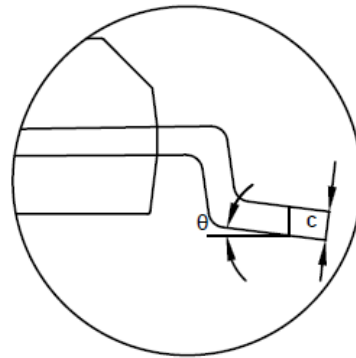
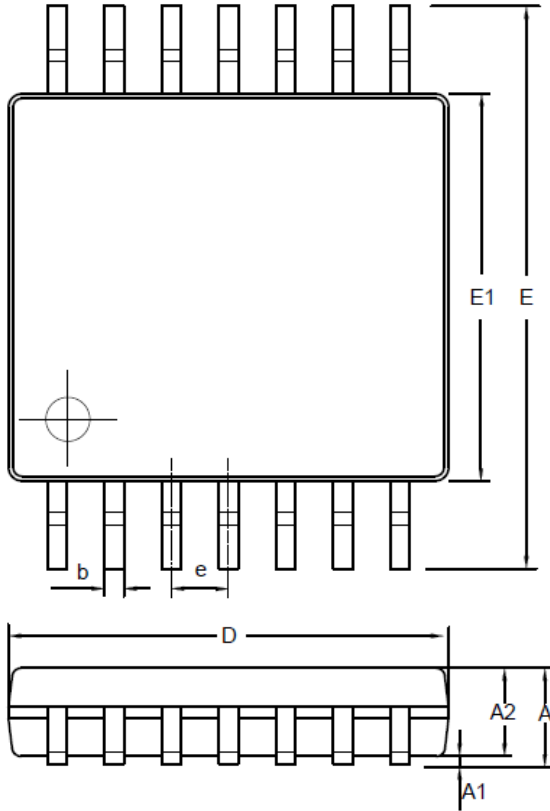
# TP2301 / TP2302 / TP2304

## 20MHz Bandwidth, Low Noise High Precision Op-amps

### TSSOP14

#### Package Outline Dimensions

#### TS2(TSSOP-14-A)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.200	0.035	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	4.900	5.100	0.193	0.201
E	6.200	6.600	0.244	0.260
E1	4.300	4.500	0.169	0.177
e	0.650 BSC		0.026 BSC	
L	0.450	0.750	0.018	0.030
theta	0	8°	0	8°

#### NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

Revision History

Date	Revision	Notes
2022/4/29	A.4	Update order information. Update EC table: VOL/VOH: typ 13mV -> 20mV; max 20mV -> 50mV Iq of TP2301(1ch): typ 5mA, max 9mA Slew Rate: min 18 -> 15
2023/5/29	A.5	The following updates are all about the new datasheet formats or typo, the actual product remains unchanged. Updated to new format of package dimensions and tape and reel information. Updated Absolute Maximum Ratings, added differential input voltage. Updated address of web site. Updated the HBM value from 6kV to 4kV, CDM value from 2kV to 1.5kV due to new test standard.