Features

- Gain-bandwidth Product: 10 MHz
- Low Noise: 8.2 nV/√Hz(f= 1 kHz)
- Slew Rate: 7 V/μs
- Offset Voltage: 1 mV (max)
- EMIRR IN+: 88 dB(under 2.4 GHz)
- Low THD+N: 0.0005%
- Supply Range: 2.2 V to 5.5 V
- Supply Current: 1.4 mA/ch
- Low Input Bias Current: 0.3 pA Typical
- Rail-to-Rail I/O
- High Output Current: 70 mA (1.0 V Drop)

Applications

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

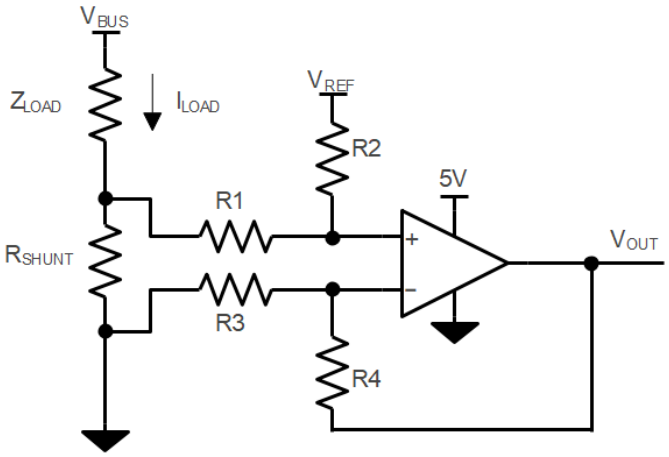
Description

The TP2411, TP2412, and TP2414 are low-cost, single, dual, and quad rail-to-rail output, single-supply amplifiers featuring low offset and input voltages, low-current noise, and wide signal bandwidth. The combination of low offset, low noise, very low input bias currents, and high speed make these amplifiers useful in a wide variety of applications. Filters, integrators, photodiode amplifiers, and high impedance sensors all benefit from this combination of performance features. Audio and other ac applications benefit from the wide bandwidth and low distortion of these devices.

Applications for these amplifiers include power amplifier (PA) controls, laser diode control loops, portable and loop-powered instrumentation, audio amplification for portable devices, and ASIC input and output amplifiers.

The TP2411 is the single-channel version available in 8-pin SOP and 5-pin SOT23 packages. The TP2412 is the dual-channel version available in 8-pin SOP, SOT, TSSOP, and MSOP packages. The TP2414 is the quad-channel version available in 14-pin SOP and TSSOP packages.

Typical Application Circuit



$V_{OUT} = (I_{LOAD} \times R_{SHUNT}) \times (R2 / R1) + V_{REF}$

When R3 = R1, R2 = R4, $R_{SHUNT} << R1$

Table of Contents

Revision History

Date	Revision	Notes
2022/04/30	Rev.B.5	Updated order information.
2022/07/18	Rev.B.6	Updated to new document format. Updated package dimensions.
2022/08/09	Rev.B.7	Correct typo error of MSL level, no product change.

Pin Configuration and Functions

TP2411
5-Pin SOT23 Package
Top View

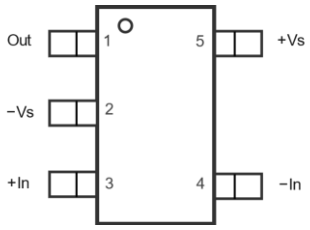
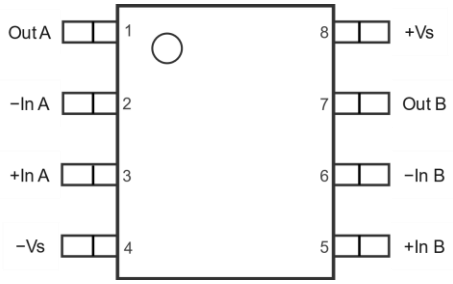


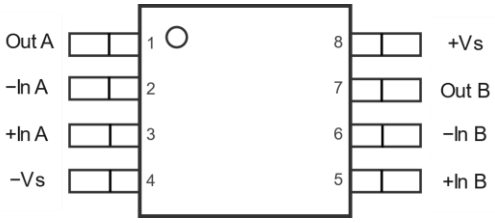
Table 6-1. Pin Functions: TP2411

Pin	Name	I/O	Description
SOT23			
1	Out	Output	Output
2	$-V_S$		Negative power supply
3	+In	Input	Noninverting input
4	−In	Input	Inverting input
5	$+V_S$		Positive power supply

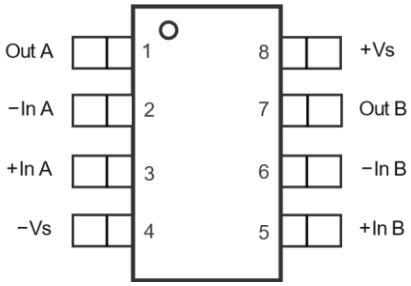
TP2412
SOP8 Package
Top View



TP2412
MSOP8 Package
Top View



TP2412
SOT23-8 Package
Top View

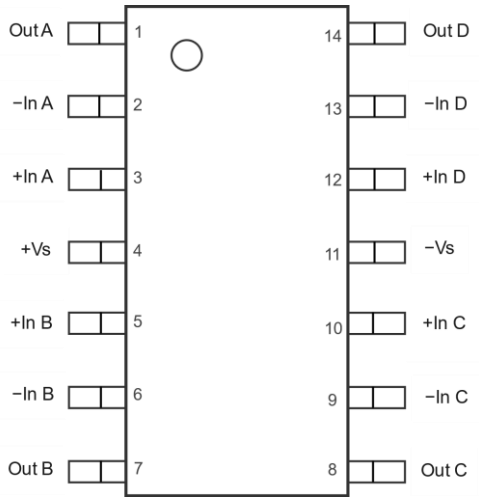


TP2412
TSSOP8 Package
Top View

Table 6-2. Pin Functions: TP2412

Pin	Name	I/O	Description
1	Out A	Output	Output
2	−In A	Input	Inverting input
3	+In A	Input	Noninverting input
4	$-V_S$		Negative power supply
5	+In B	Input	Noninverting input
6	−In B	Input	Inverting input
7	Out B	Output	Output
8	$+V_S$		Positive power supply

TP2414
SOP14 Package
Top View



TP2414
TSSOP14 Package
Top View

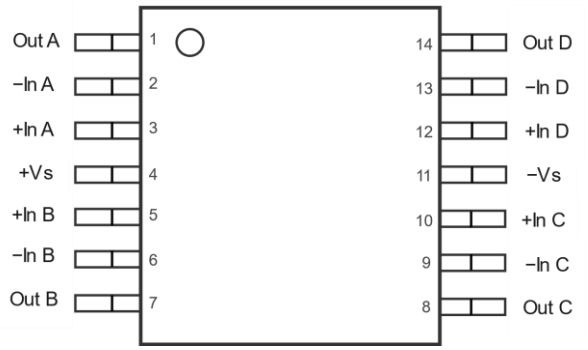


Table 6-3. Pin Functions: TP2414

Pin	Name	I/O	Description
1	Out A	Output	Output
2	−In A	Input	Inverting input
3	+In A	Input	Noninverting input
4	$+V_S$		Positive power supply
5	+In B	Input	Noninverting input
6	−In B	Input	Inverting input
7	Out B	Output	Output
8	Out C	Output	Output
9	−In C	Input	Inverting input
10	+In C	Input	Noninverting input
11	$-V_S$		Negative power supply
12	+In D	Input	Noninverting input
13	−In D	Input	Inverting input
14	Out D	Output	Output

Specifications

Absolute Maximum Ratings(1)

Parameter		Min	Max	Unit
	Supply Voltage: $V^+ - V^-$(2)		7	V
	Input Voltage	$V^- - 0.3$	$V^+ + 0.3$	V
	Input Current: +IN, –IN(3)	−20	+20	mA
	Output Short-Circuit Duration(4)		Indefinite	
	Current at Supply Pins	−60	+60	mA
T_J	Maximum Junction Temperature		150	°C
T_A	Operating Temperature Range	−40	125	°C
T_{STG}	Storage Temperature Range	−65	150	°C
T_L	Lead Temperature (Soldering 10 sec)		260	°C

(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.

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

(3) The inputs and outputs are protected by ESD protection diodes to the negative power supply. If the input or output extends more than 500 mV beyond the negative power supply, the current should be limited to less than 10 mA.

(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 comparators 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	kV

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
SOT23-5	250	81	°C/W
SOP8	158	43	°C/W
MSOP8	210	45	°C/W
TSSOP8	191	50	°C/W
SOT23-8	196	70	°C/W
SOP14	120	36	°C/W
TSSOP14	180	35	°C/W

Electrical Characteristics

All test condition is T_A = 27°C. V_S = 5 V, R_L = 2 kΩ, C_L =100 pF, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{OS}	Input Offset Voltage	V_{CM} = V_S/2	-1	±0.25	+1	mV
		V_{CM} = 0V	-1	±0.25	+1	mV
V_{OS} TC	Input Offset Voltage Drift	-40°C to 125°C		1		μV/°C
I_B	Input Bias Current	T_A = 27 °C		0.3		pA
		T_A = 85 °C		150		pA
		T_A = 125 °C		300		pA
I_{OS}	Input Offset Current			0.3		pA
V_n	Input Voltage Noise	f = 0.1 Hz to 10 Hz		3.14		μV_{PP}
e_n	Input Voltage Noise Density	f = 1 kHz		8.2		nV/√Hz
i_n	Input Current Noise	f = 1 kHz		2		fA/√Hz
C_{IN}	Input Capacitance	Differential Common Mode		8 7		pF
CMRR	Common Mode Rejection Ratio	V_{CM} = 2.5 V	90	106		dB
		V_{CM} = 0 V to 3 V	80	106		dB
		V_{CM} = 0 V to 5 V	55	72		dB
V_{CM}	Common-mode Input Voltage Range		V^- – 0.1		V^+ + 0.1	V
PSRR	Power Supply Rejection Ratio	V_S = 2.2 V to 5.5 V, V_{CM} = 0 V	82	100		dB
A_{VOL}	Open-Loop Large Signal Gain	R_{LOAD} = 2 kΩ, V_{OUT} = -2 V to 2 V	100	120		dB
V_{OL}, V_{OH}	Output Swing from Supply Rail	R_{LOAD} = 2 kΩ		20	50	mV
R_{OUT}	Closed-Loop Output Impedance	G = 1, f =1 MHz, I_{OUT} = 0		0.2		Ω
R_O	Open-Loop Output Impedance	f = 1 kHz, I_{OUT} = 0		125		Ω
I_{SC}	Output Short-Circuit Current	Sink or source current	100	130		mA
V_S	Supply Voltage		2.2		5.5	V
I_Q	Quiescent Current per Amplifier	V_S = 5 V		1.4	1.95	mA
PM	Phase Margin	R_{LOAD} = 1 kΩ, C_{LOAD} = 60 pF		60		°
GM	Gain Margin	R_{LOAD} = 1 kΩ, C_{LOAD} = 60 pF		8		dB
GBWP	Gain-Bandwidth Product	f = 1kHz		10		MHz
SR	Slew Rate	A_V = 1, C_{LOAD} = 100 pF, R_{LOAD} = 2 kΩ	3.0	7		V/μs

FPBW	Full Power Bandwidth **Note 1**			414		kHz
t_S	Settling Time, 0.1% Settling Time, 0.01%	A_V = –1, 1 V Step		0.75 0.85		µs
THD+N	Total Harmonic Distortion and Noise	f = 1 kHz, A_V =1, R_{LOAD} = 2 kΩ, V_{OUT} = 1Vp-p		0.0005		%
X_{talk}	Channel Separation	f = 1 kHz, R_L = 2 kΩ		110		dB

(1) Full power bandwidth is calculated from the slew rate FPBW = SR/π • VP-P.

Typical Performance Characteristics

V_S = ±2.75 V, V_{CM} = 0 V, R_L = Open, unless otherwise specified.

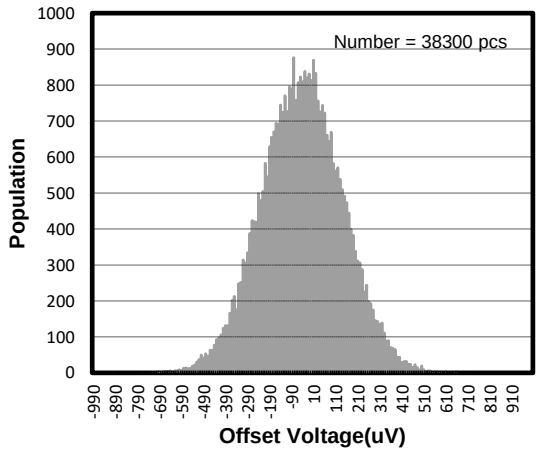


Figure 1. Offset Voltage Production Distribution

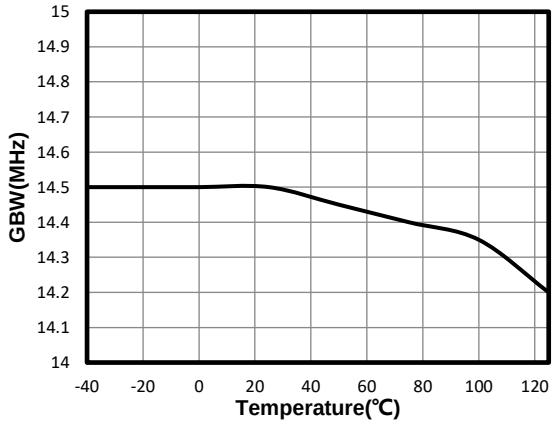


Figure 2. Unity Gain Bandwidth vs. Temperature

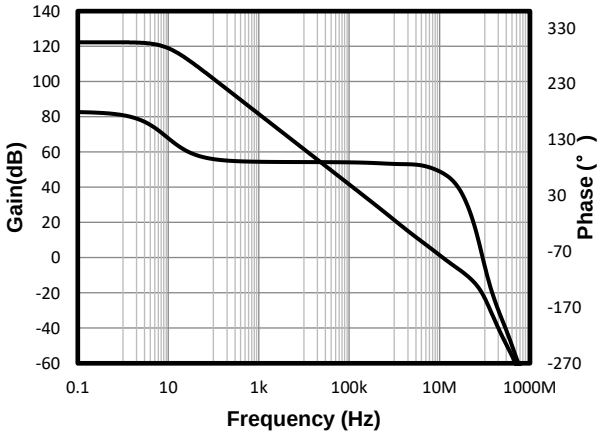


Figure 3. Open-Loop Gain and Phase

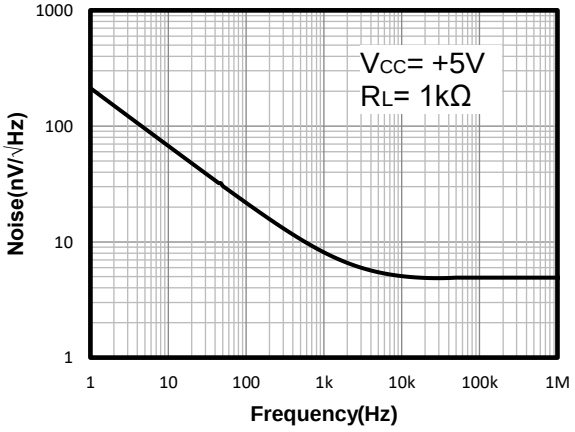


Figure 4. Input Voltage Noise Spectral Density

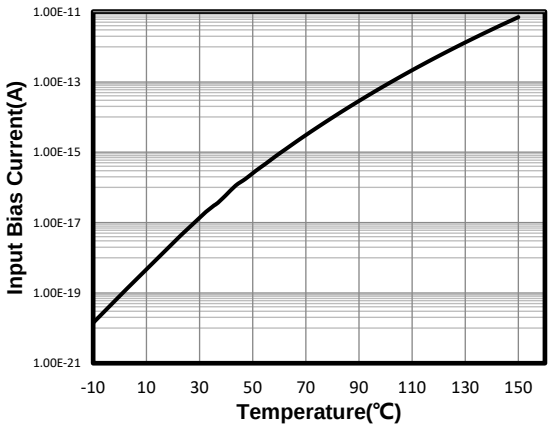


Figure 5. Input Bias Current vs. Temperature

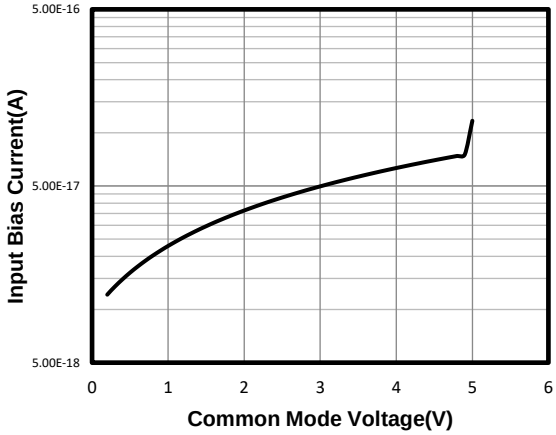


Figure 6. Input Bias Current vs. Common-Mode Voltage

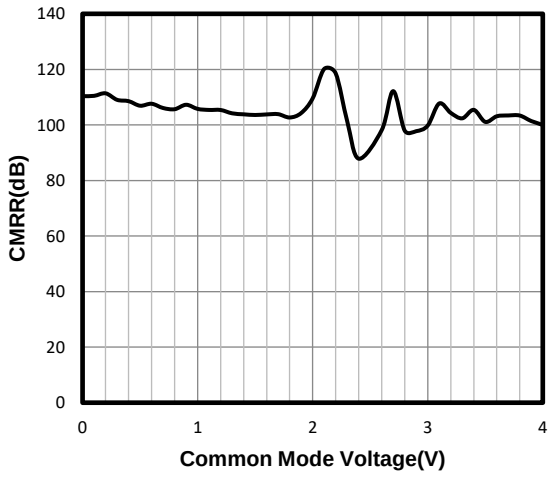


Figure 7. Common-Mode Rejection Ratio

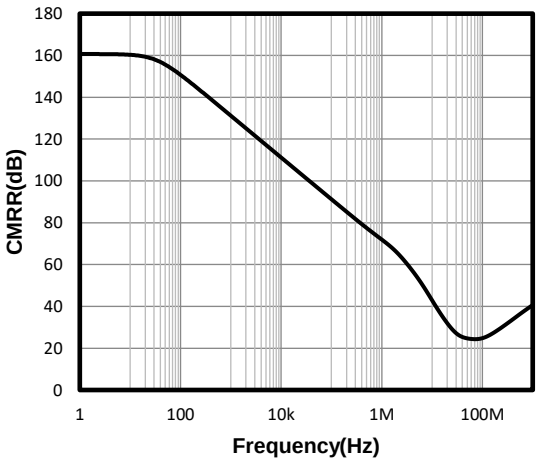


Figure 8. CMRR vs. Frequency

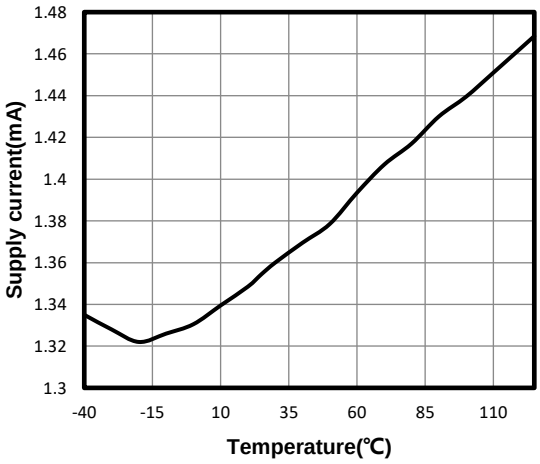


Figure 9. Power-Supply Rejection Ratio

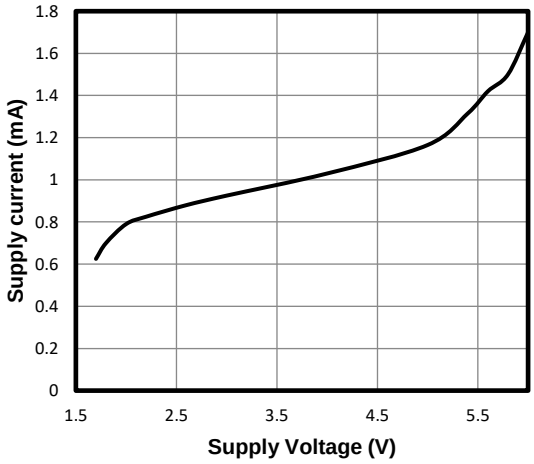


Figure 10. Quiescent Current vs. Supply Voltage

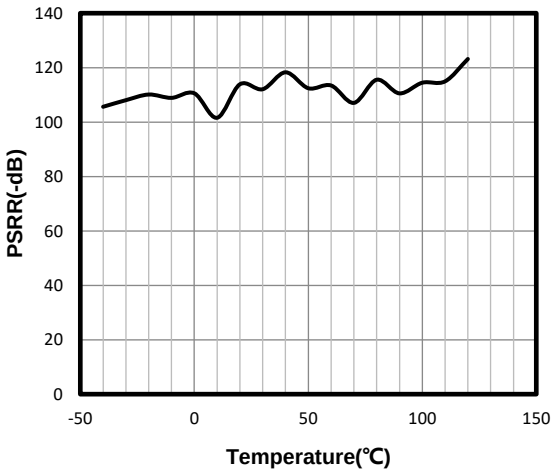


Figure 11. Power-Supply Rejection Ratio vs. Temperature

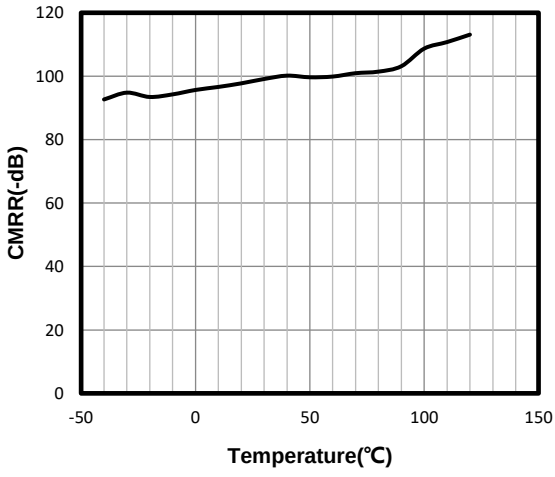


Figure 12. CMRR vs. Temperature

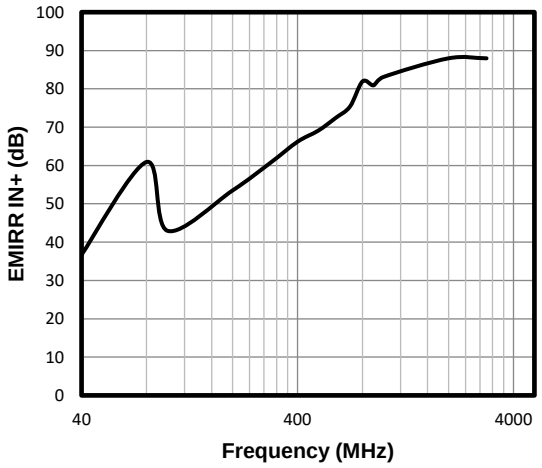


Figure 13. EMIRR IN+ vs. Frequency

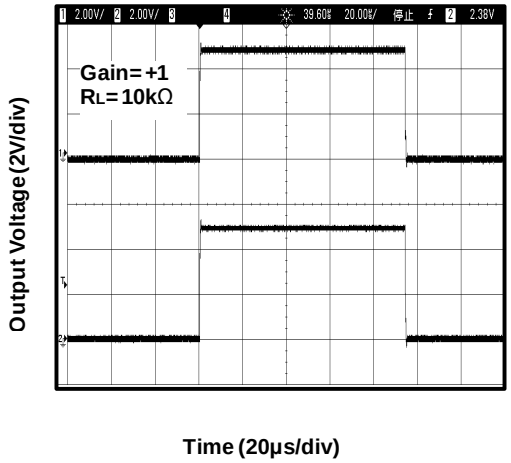


Figure 14. Large-Scale Step Response

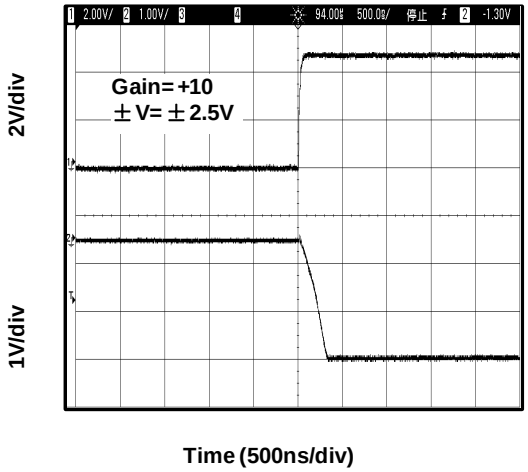


Figure 15. Negative Over-Voltage Recovery

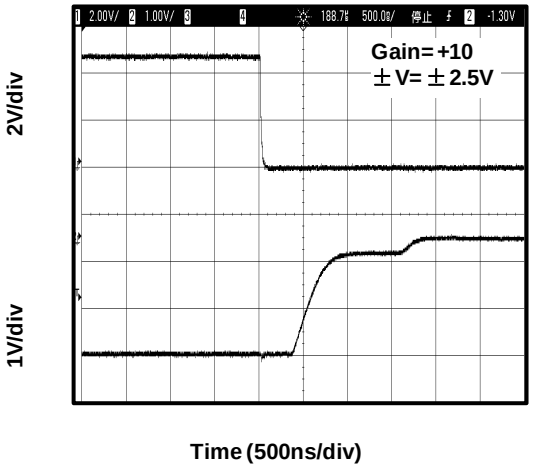


Figure 16. Positive Over-Voltage Recovery

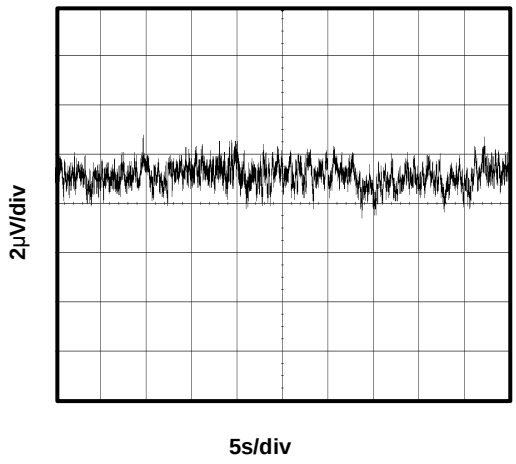


Figure 17. 0.1 Hz TO 10 Hz Input Voltage Noise

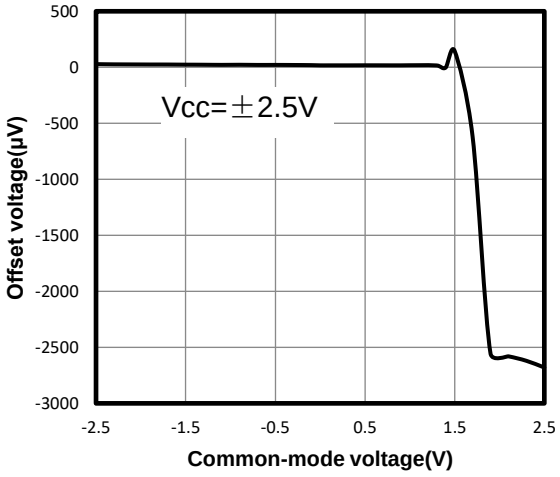


Figure 18. Offset Voltage vs Common-Mode Voltage

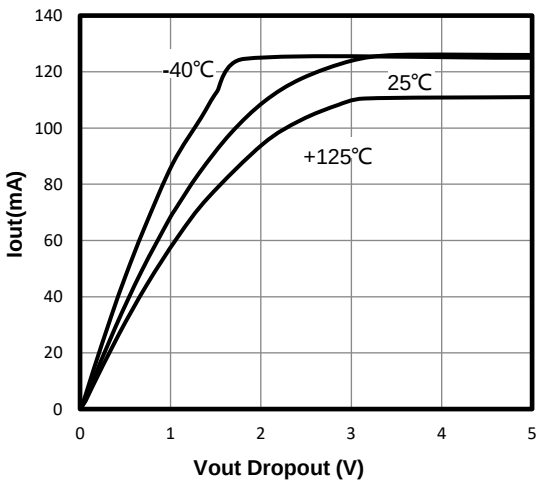


Figure 19. Positive Output Swing vs. Load Current

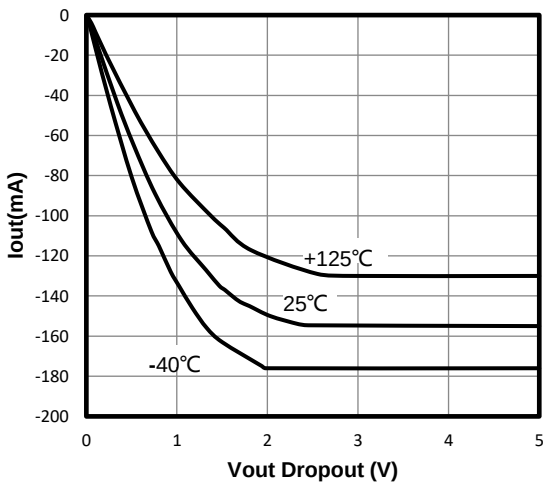


Figure 20. Negative Output Swing vs. Load Current

Detailed Description

Overview

The TP2411 series op amps can operate on a single-supply voltage (2.2 V to 5.5 V), or a split-supply voltage (±1.1 V to ±2.75 V), making them highly versatile and easy to use. The power-supply pins should have local bypass ceramic capacitors (typically 0.001 µF to 0.1 µF). These amplifiers are fully specified from +2.2 V to +5.5 V and over the extended temperature range of –40°C to +125°C. Parameters that can exhibit variance with regard to operating voltage or temperature are presented in the Typical Characteristics.

Functional Block Diagram

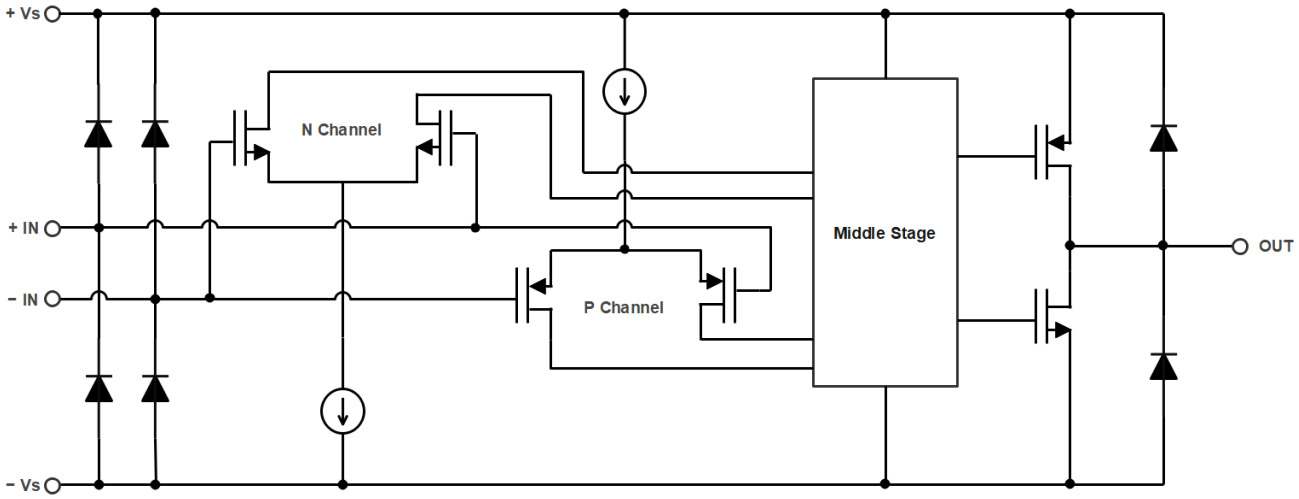


Figure 21. Functional Block Diagram

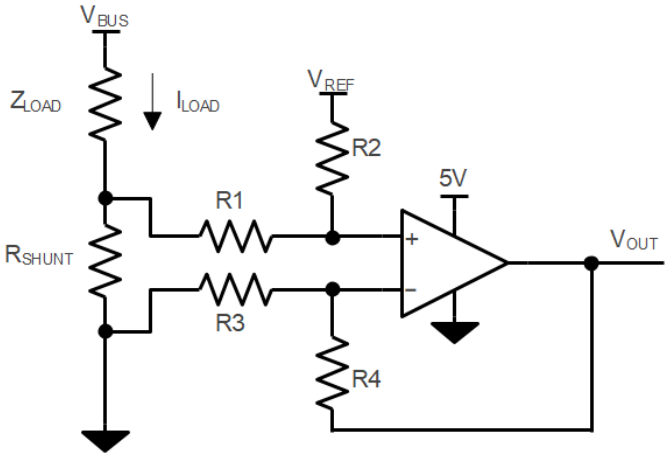
Application and Implementation

NOTE

Information in the following applications sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

Low Side Current Sensing Application

Figure 22 shows the TP241X configured in a low-side current sensing application. The low-side current sensing method consists of placing a sense resistor between the load and the circuit ground. The voltage dropping across the resistor is amplified by different amplifier circuits with TP241X. The V_{REF} can be used to add bias voltage to output voltage. Particular attention must be paid to the matching and precision of R1, R2, R3, and R4, to maximize the accuracy of the measurement.



$$V_{OUT} = (I_{LOAD} \times R_{SHUNT}) \times (R2 / R1) + V_{REF}$$

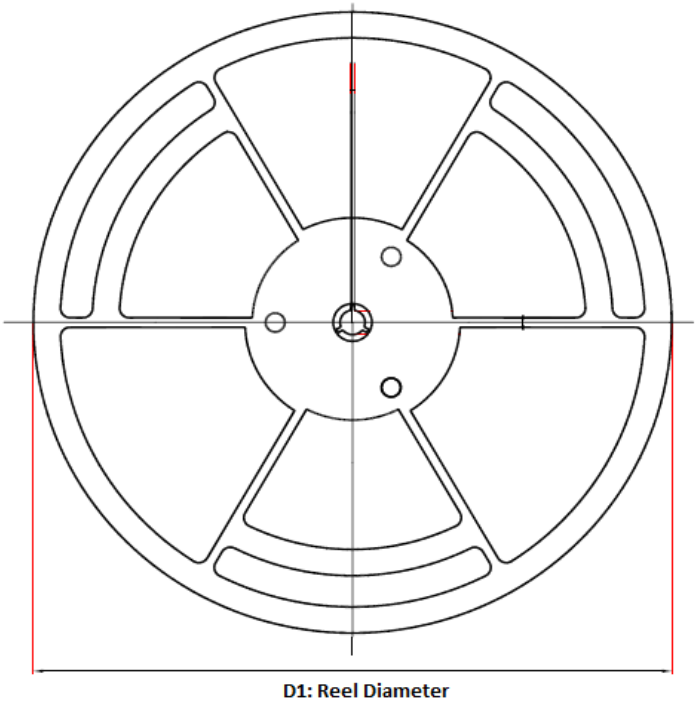
When R3 = R1, R2 = R4, $R_{SHUNT} << R1$

Figure 22 Dual Supply Operation Connections

Power Supply Recommendations

Place 0.1-μF bypass capacitors close to the power supply pins for reducing coupling errors from the noisy or high impedance power supplies.

Tape and Reel Information

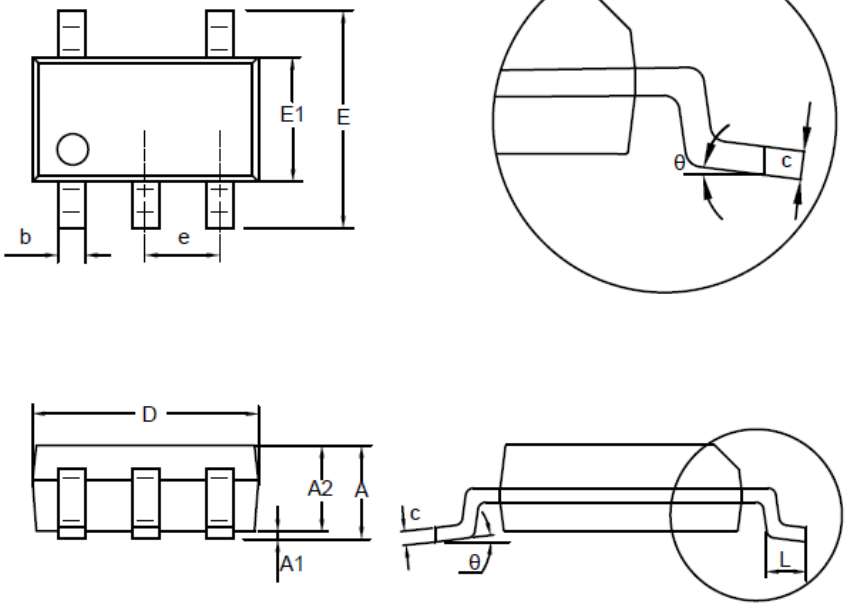


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TP2411-TR	SOT23-5	180.0	13.1	3.2	3.2	1.4	4.0	8.0	Q3
TP2412-SR	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TP2412-VR	MSOP8	330.0	17.6	5.2	3.3	1.5	8.0	12.0	Q1
TP2412-TR	SOT23-8	178.0	12.3	3.2	3.2	1.4	4.0	8.0	Q3
TP2412-TSR	TSSOP8	330.0	17.6	6.8	3.3	1.2	8.0	12.0	Q1
TP2414-SR	SOP14	330.0	21.6	6.5	9.0	2.1	8.0	16.0	Q1
TP2414-TR	TSSOP14	330.0	17.6	6.8	5.4	1.2	8.0	12.0	Q1

Package Outline Dimensions

SOT23-5

Package Outline Dimensions S5T(SOT23-5-A)



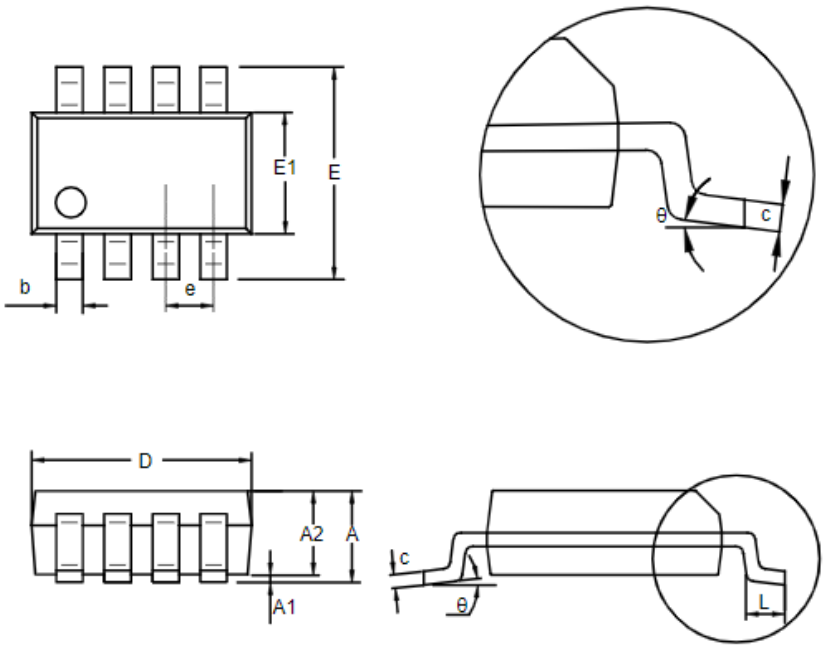
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.280	0.500	0.011	0.020
c	0.100	0.230	0.004	0.009
D	2.820	3.020	0.111	0.119
E	2.600	3.000	0.102	0.118
E1	1.500	1.720	0.059	0.068
e	0.950 BSC		0.037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

NOTES

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

SOT23-8

Package Outline Dimensions T8T(SOT23-8-A)



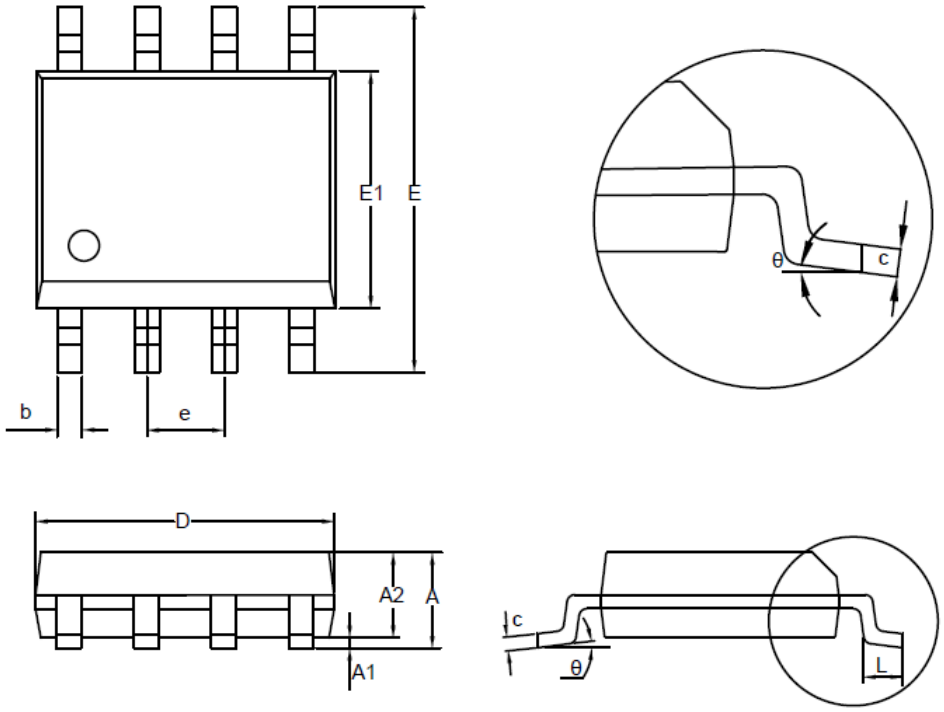
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.280	0.500	0.011	0.020
c	0.100	0.230	0.004	0.009
D	2.820	3.020	0.111	0.119
E	2.600	3.000	0.102	0.118
E1	1.500	1.720	0.059	0.068
e	0.650 BSC		0.026 BSC	
L	0.300	0.600	0.012	0.024
θ	0	8°	0	8°

NOTES

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

SOP8

Package Outline Dimensions SO1(SOP-8-A)



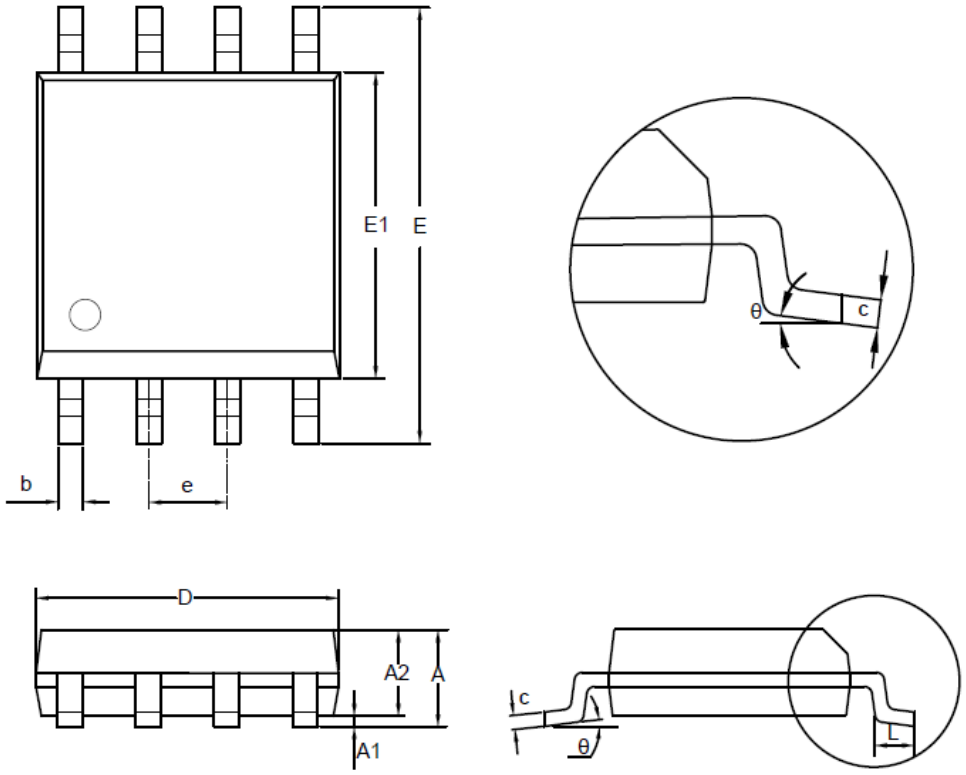
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050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

NOTES

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

MSOP8

Package Outline Dimensions VS1(MSOP-8-A)



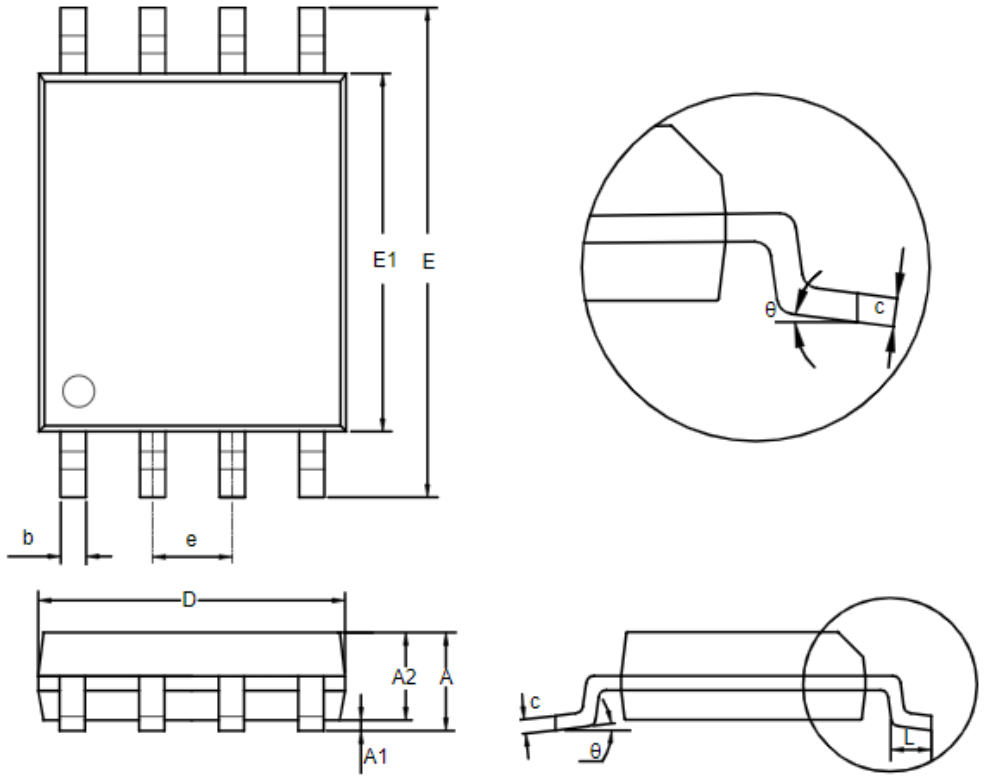
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.050	0.150	0.002	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.650 BSC		0.026 BSC	
L	0.400	0.800	0.016	0.031
θ	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 TS1(TSSOP-8-A)



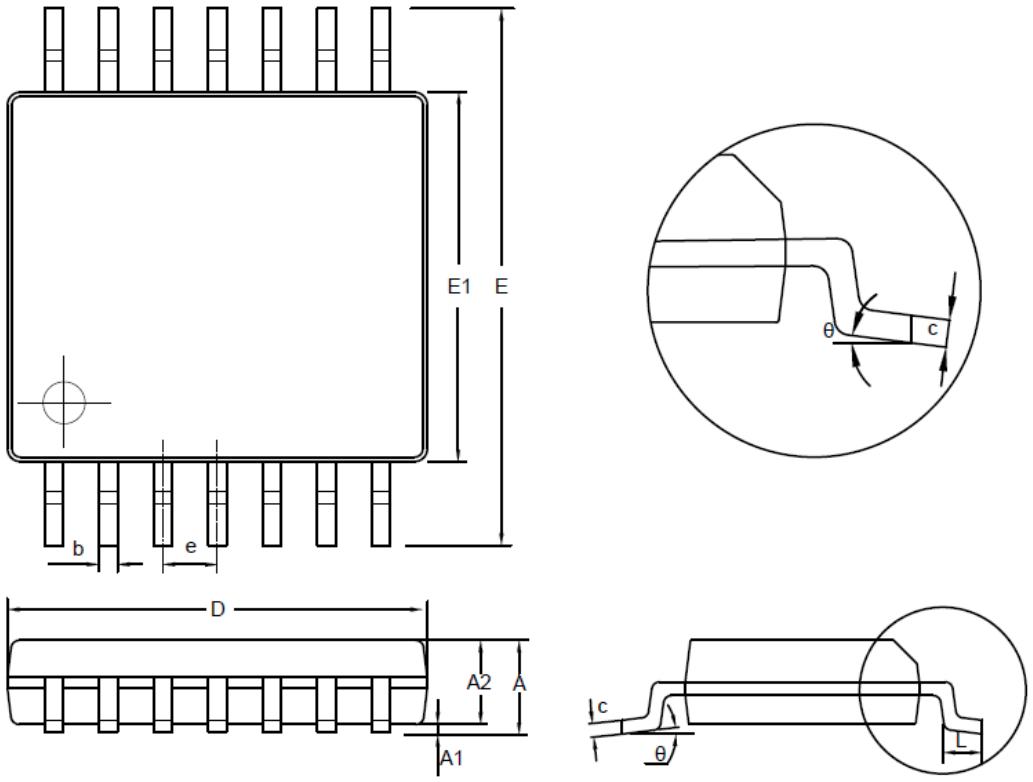
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.200	0.035	0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	2.900	3.100	0.114	0.122
E	6.200	6.600	0.244	0.260
E1	4.300	4.500	0.169	0.177
e	0.650 BSC		0.026 BSC	
L	0.450	0.750	0.018	0.030
θ	0	8°	0	8°

NOTES

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

TSSOP14

Package Outline Dimensions TS2(TSSOP-14-A)



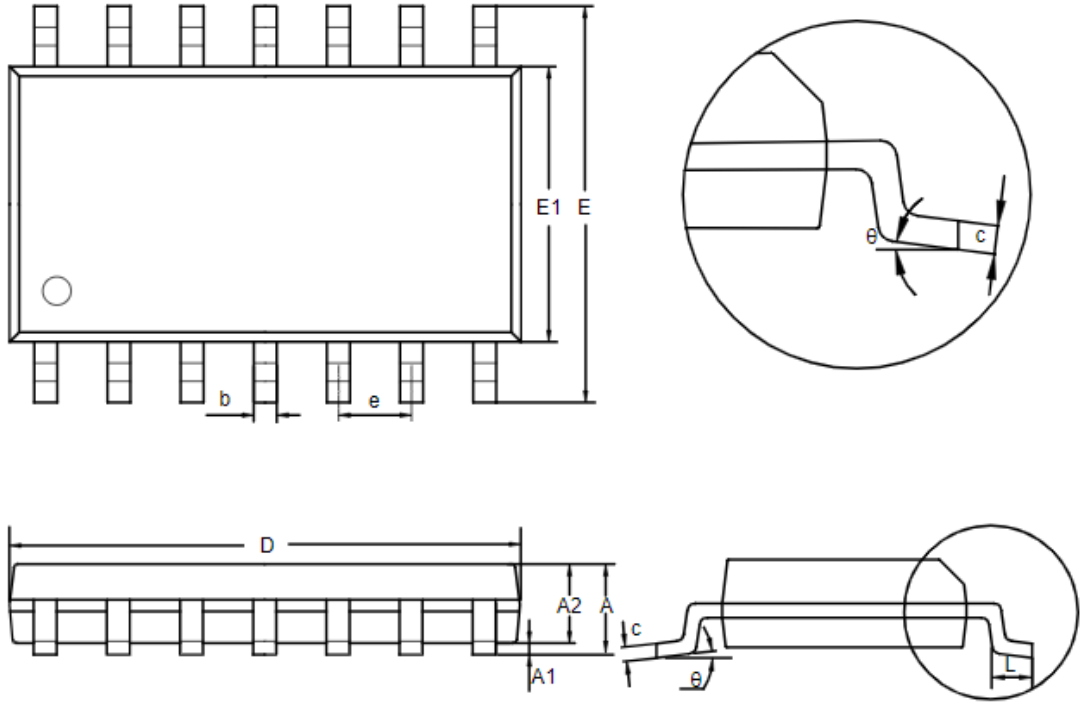
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.200	0.035	0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.900	5.100	0.193	0.201
E	6.200	6.600	0.244	0.260
E1	4.300	4.500	0.169	0.177
e	0.650 BSC		0.026 BSC	
L	0.450	0.750	0.018	0.030
θ	0	8°	0	8°

NOTES

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

SOP14

Package Outline Dimensions SO2(SOP-14-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	1.650	0.049	0.065
b	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D	8.450	8.850	0.333	0.348
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	1.270	0.016	0.050
θ	0	8°	0	8°

NOTES

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

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transpor Quar
TP2411-TR	-40 to 125°C	SOT23-5	411	3	Tape and R
TP2412-SR	-40 to 125°C	SOP8	TP2412	3	Tape and R
TP2412-VR	-40 to 125°C	MSOP8	TP2412	3	Tape and R
TP2412-TSR	-40 to 125°C	TSSOP8	TP2412	3	Tape and R
TP2412-TR	-40 to 125°C	SOT23-8	S12	3	Tape and R
TP2414-SR	-40 to 125°C	SOP14	TP2414	3	Tape and R
TP2414-TR	-40 to 125°C	TSSOP14	TP2414	3	Tape and R

Green: 3PEAK defines "Green" to mean RoHS compatible and free of halogen substances.