

Features

- Supply Voltage: 2.5 V to 6 V
- Low Supply Current: Typical 600-μA per Channel
- Rail-to-Rail Input and Output
- Bandwidth: Typical 6 MHz
- Slew Rate: Typical 4.5 V/μs
- Excellent EMI Suppress Performance
- Offset Voltage: Maximum ±3 mV
- Offset Voltage Temperature Drift: Typical 1 μV/°C
- Low Noise: Typical 19 nV/√Hz at 1 kHz
- High Output Capability: Typical 100 mA
- -40°C to 125°C Operation Temperature Range
- Qualified for Automotive Applications with AEC-Q100 Reliability Test

Applications

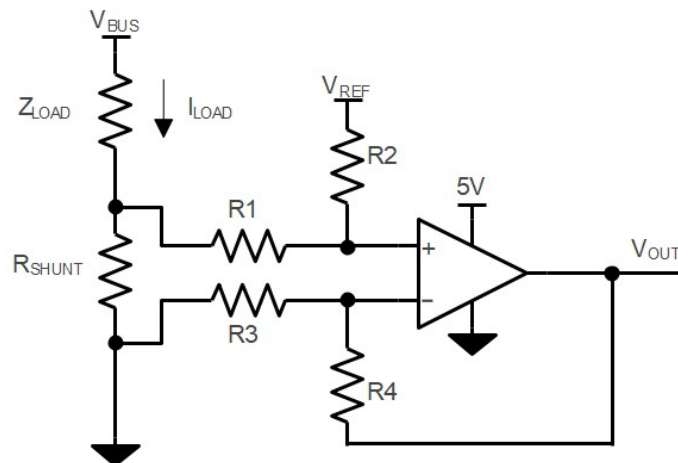
- Automotive Motor Control
- On-Board Charger

Description

The TP156xAL1 series of products are CMOS dual and quad RRIO op-amps with low offset, low power and stable high-frequency response. They incorporate 3PEAK's proprietary and patented design techniques to achieve very good AC performance with 6-MHz bandwidth, 4.5-V/μs slew rate, and low distortion while drawing only 600 μA of quiescent current per amplifier. The input common-mode voltage range extends 300 mV beyond V- and V+, and the outputs swing rail-to-rail. The TP156xAL1 family can be used as plug-in replacements for many commercially available op-amps to reduce power consumption and improve input/output range and performance.

The combination of features makes the TP156xAL1 ideal choice for motor control and automotive applications. The ability to swing rail-to-rail at the inputs and outputs enables designers to buffer CMOS DACs, ASICs, or other wide output swing devices in single-supply systems.

Typical Application Circuit



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

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

Table of Contents

Features.....	1
Applications.....	1
Description.....	1
Typical Application Circuit.....	1
Revision History.....	3
Pin Configuration and Functions.....	4
Specifications.....	7
Absolute Maximum Ratings ⁽¹⁾	7
ESD, Electrostatic Discharge Protection.....	7
Recommended Operating Conditions.....	7
Thermal Information.....	7
Electrical Characteristics.....	8
Typical Performance Characteristics.....	10
Detailed Description.....	13
Functional Block Diagram.....	13
Application and Implementation.....	14
Application Information	14
Tape and Reel Information.....	15
Package Outline Dimensions.....	16
SOT23-5.....	16
SOP8.....	17
MSOP8.....	18
SOP14.....	19
TSSOP14.....	20
Order Information.....	21
IMPORTANT NOTICE AND DISCLAIMER.....	22

Revision History

Date	Revision	Notes
2022-11-20	Rev.A.0	Initial version.
2023-02-01	Rev.A.1	Updated the status of AEC-Q100 test in Features.
2023-02-15	Rev.A.2	Corrected typo.
2023-09-15	Rev.A.3	Update the max value of supply voltage from 5.5V to 6V.
2024-07-25	Rev.A.4	Added part number: TPA1564AL1-TS2R-S. The following updates in Recommended Operating Conditions and Electrical Characteristics are all finished in Rev.A.3. Supply Voltage Range: from Min 2.7, Max 5.5 to Min 2.5, Max 6. Input Offset Voltage, VCM = 0 V to 3 V, TA = -40°C to 125°C: from Min -5, Max 5 to Min -4, Max 4. Input Offset Current: from Typ 10 to Typ 1. Maximum Output Voltage Swing, RLOAD = 10 k Ω , TA = -40°C to 125°C: from Max 30 to Max 20. Output Short-Circuit Current, TA = -40°C to 125°C: from Min 50 to Min 65. Slew Rate: Added Min 3 in TA = 25°C and Min 2 in TA = -40°C to 125°C.

Pin Configuration and Functions

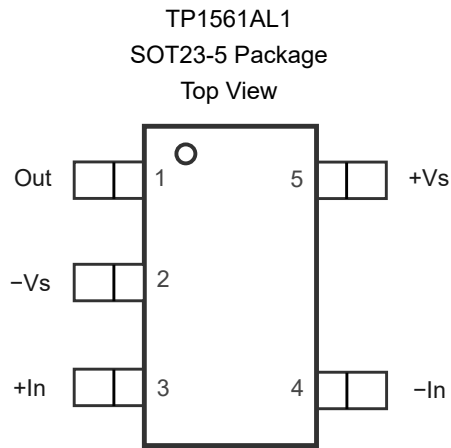


Table 1. Pin Functions: TP1561AL1

Pin No.	Name	I/O	Description
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

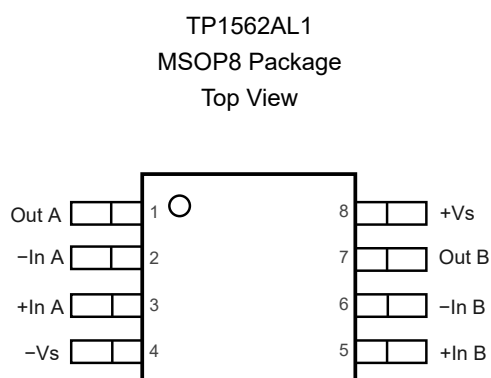
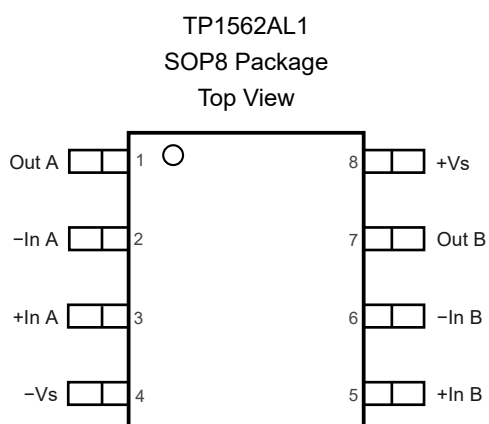


Table 2. Pin Functions: TP1562AL1

Pin No.	Name	I/O	Description
1	Out A	Output	Output
2	-In A	Input	Inverting input
3	+In A	Input	Noninverting input
4	-Vs	-	Negative power supply
5	+In B	Input	Noninverting input
6	-In B	Input	Inverting input
7	Out B	Output	Output
8	+Vs	-	Positive power supply

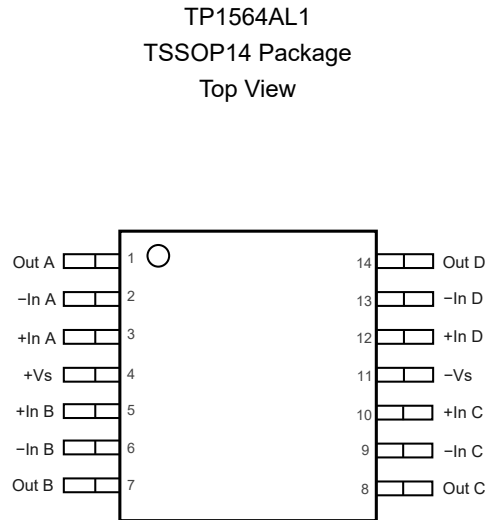
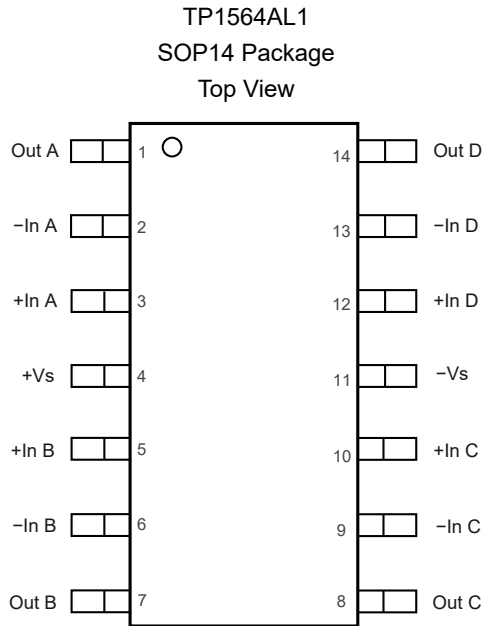


Table 3. Pin Functions: TP1564AL1

Pin No.	Name	I/O	Description
1	Out A	Output	Output
2	-In A	Input	Inverting input
3	+In A	Input	Noninverting input
4	+Vs	-	Positive power supply
5	+In B	Input	Noninverting input
6	-In B	Input	Inverting input
7	Out B	Output	Output power supply
8	Out C	Output	Output power supply
9	-In C	Input	Inverting input
10	+In C	Input	Noninverting input
11	-Vs	-	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 _S) – (–V _S)		6.5	V
	Input Voltage	(–V _S) – 0.3	(+V _S) + 0.3	V
	Differential Input Voltage	(–V _S) – (+V _S)	(+V _S) – (–V _S)	V
	Input Current: +I _N , –I _N ⁽²⁾	–10	+10	mA
	Output Short-Circuit Duration ⁽³⁾		Infinite	
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 inputs are protected by ESD protection diodes to each power supply. If the input extends more than 300 mV beyond the power supply, the input current should be limited to less than 10 mA.

(3) 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

Parameter		Condition	Minimum Level	Unit
HBM	Human Body Model ESD	AEC-Q100-002	4	kV
CDM	Charged Device Model ESD	AEC-Q100-011	1.5	kV

Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V _S	Supply Voltage, (+V _S) – (–V _S)	2.5		6	V
T _A	Operating Temperature Range	–40		125	°C

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
SOP14	120	36	°C/W

Electrical Characteristics

All test condition is at $V_S = 5\text{ V}$, $T_A = 25^\circ\text{C}$, $R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, unless otherwise noted.

Parameter		Conditions	Min	Typ	Max	Unit
Power Supply						
V _S	Supply Voltage Range		2.5		6	V
I _Q	Quiescent Current per Amplifier			600	900	μA
		T _A = −40°C to 125°C			1200	μA
PSRR	Power Supply Rejection Ratio	V _S = 2.7 V to 5.5 V, V _{CM} = 0.1 V	75	90		dB
		V _S = 2.7 V to 5.5 V, V _{CM} = 0.1 V, T _A = −40°C to 125°C	65			dB
Input Characteristics						
V _{OS}	Input Offset Voltage	V _{CM} = 0 V to 3 V	−3		3	mV
V _{OS}	Input Offset Voltage	V _{CM} = 0 V to 3 V, T _A = −40°C to 125°C	−4		4	mV
V _{OS} TC	Input Offset Voltage Drift	T _A = −40°C to 125°C		1		μV/°C
I _B	Input Bias Current	T _A = 25 °C	−200	1	200	pA
		T _A = 125 °C	−500	25	500	pA
I _{OS}	Input Offset Current			1		pA
C _{IN}	Input Capacitance	Differential Mode		8		pF
		Common Mode		7		pF
A _v	Open-loop Voltage Gain	V _{OUT} = 0.1 V to 4.9 V, R _{LOAD} = 100 kΩ	80	100		dB
		V _{OUT} = 0.1 V to 4.9 V, R _{LOAD} = 100 kΩ, T _A = −40°C to 125°C	70			dB
V _{CMR}	Common-mode Input Voltage Range		(−V _S) − 0.1		(+V _S) + 0.1	V
CMRR	Common Mode Rejection Ratio	V _{CM} = 0 V to 2.5 V	70	100		dB
		V _{CM} = 0 V to 2.5 V, T _A = −40°C to 125°C	60			dB
Xtalk	Channel Separation	f = 1 kHz, R _L = 2 kΩ		110		dB
Output Characteristics						
	Maximum Output Voltage Swing	R _{LOAD} = 10 kΩ, T _A = −40°C to 125°C		3	20	mV
I _{SC}	Output Short-Circuit Current	T _A = −40°C to 125°C	65	100		mA
AC Specifications						
GBW	Gain-Bandwidth Product			6		MHz
SR	Slew Rate	A _V = 1, V _{OUT} = 1.5 V to 3.5 V, C _{LOAD} = 60 pF, R _{LOAD} = 1 kΩ		4.5		V/μs

Parameter		Conditions	Min	Typ	Max	Unit
		Open loop	3	4.5		V/ μ s
		Open loop, $T_A = -40^\circ\text{C}$ to 125°C	2			V/ μ s
t_s	Settling Time, 0.1%	$A_V = 1$, 2 V Step, $C_{LOAD} = 60$ pF,		0.8		μ s
	Settling Time, 0.01%	$R_{LOAD} = 1$ k Ω		1		μ s
PM	Phase Margin	$R_{LOAD} = 1$ k Ω , $C_{LOAD} = 60$ pF		60		°
GM	Gain Margin	$R_{LOAD} = 1$ k Ω , $C_{LOAD} = 60$ pF		15		dB
Noise Performance						
E_N	Input Voltage Noise	$f = 0.1$ Hz to 10 Hz		8		μ V _{PP}
e_N	Input Voltage Noise Density	$f = 1$ kHz		19		nV/ $\sqrt{\text{Hz}}$
i_N	Input Current Noise	$f = 1$ kHz		2		fA/ $\sqrt{\text{Hz}}$

Typical Performance Characteristics

All test condition: $V_S = 5\text{ V}$, $V_{CM} = 2.5\text{ V}$, $R_L = \text{Open}$, unless otherwise noted.

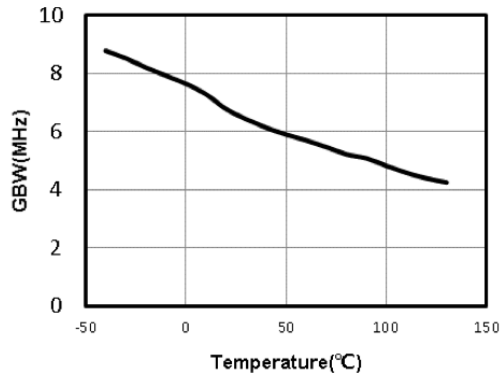


Figure 1. Unity Gain Bandwidth vs. Temperature

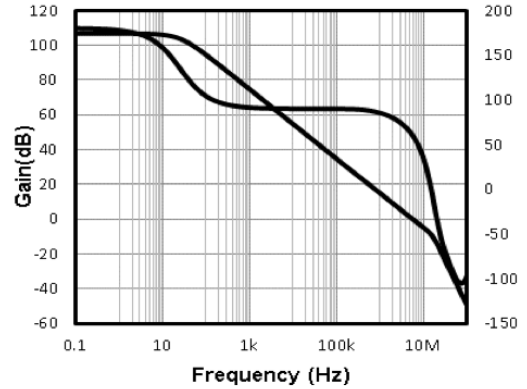


Figure 2. Open-Loop Gain and Phase

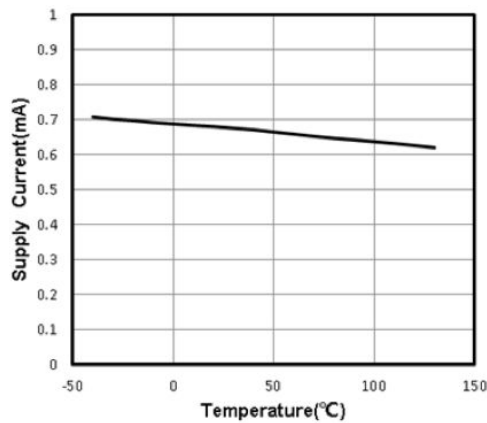


Figure 3. Supply Current vs. Temperature

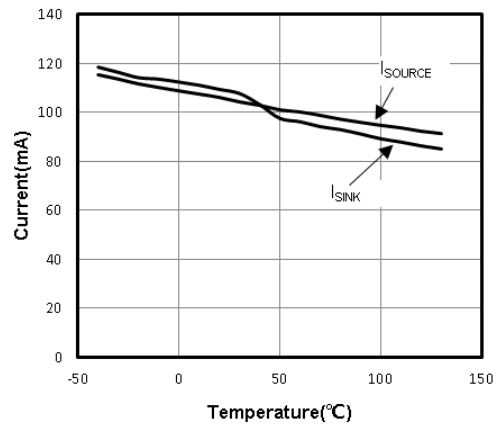


Figure 4. Short Circuit Current vs. Temperature

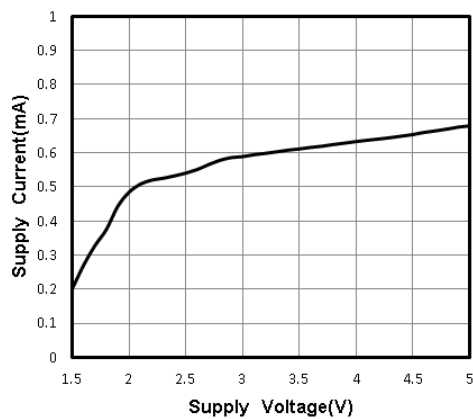


Figure 5. Quiescent Current vs. Supply Voltage

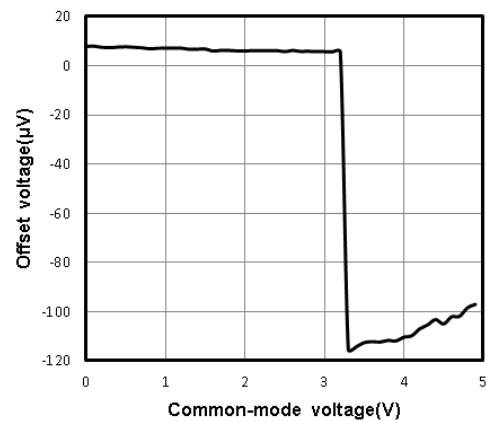
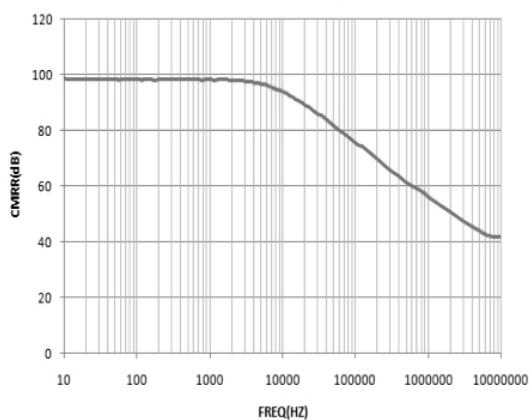
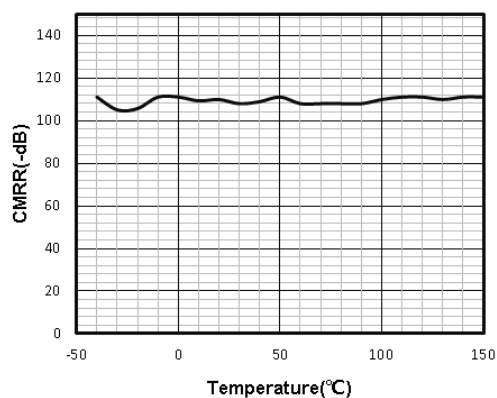
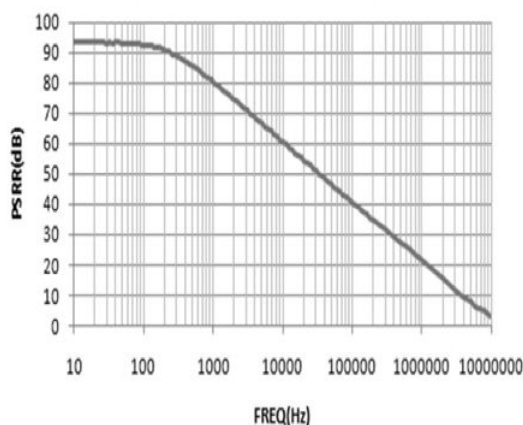
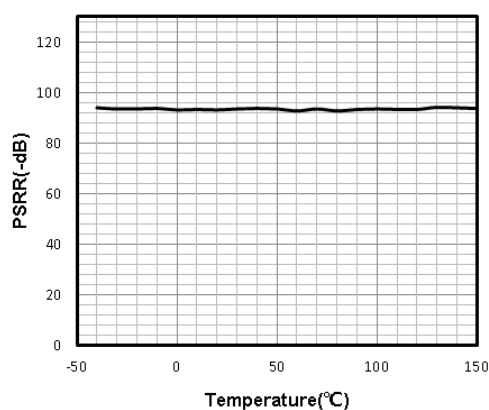
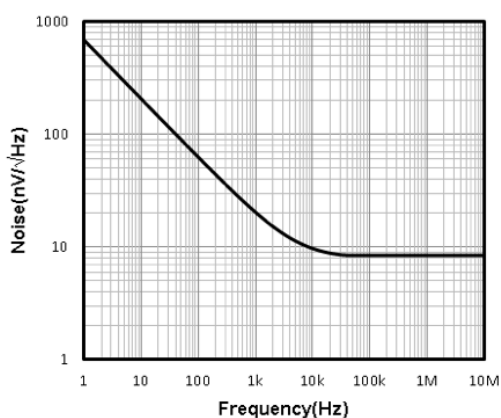
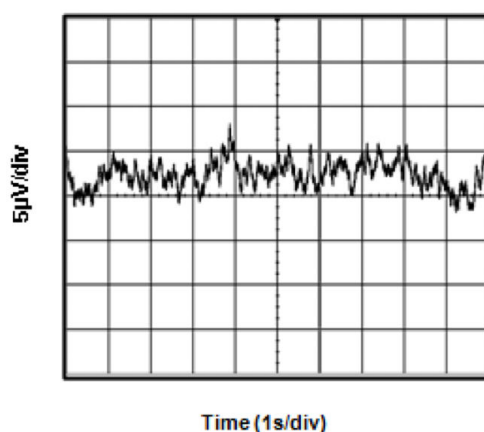
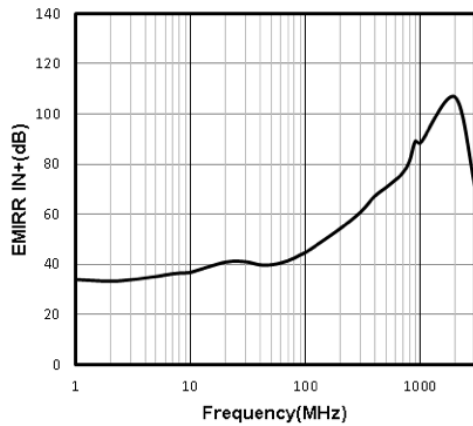
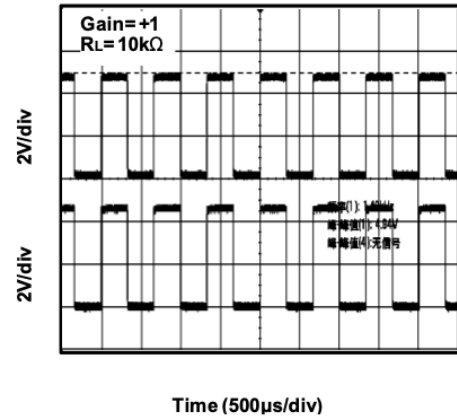
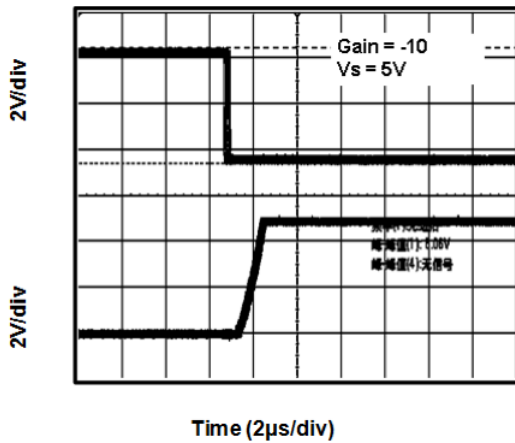
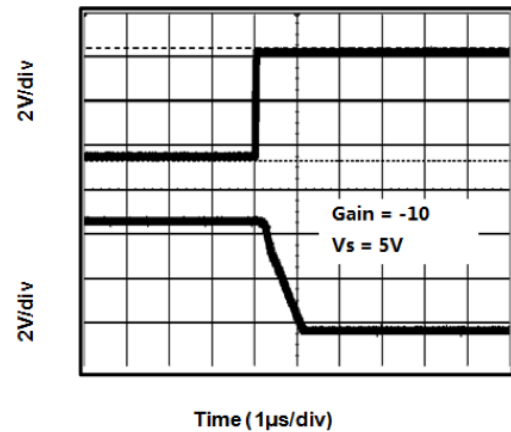
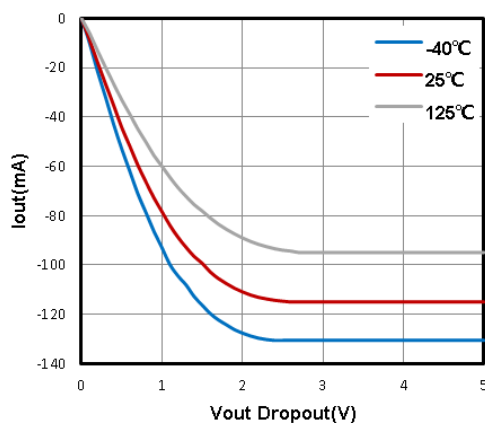
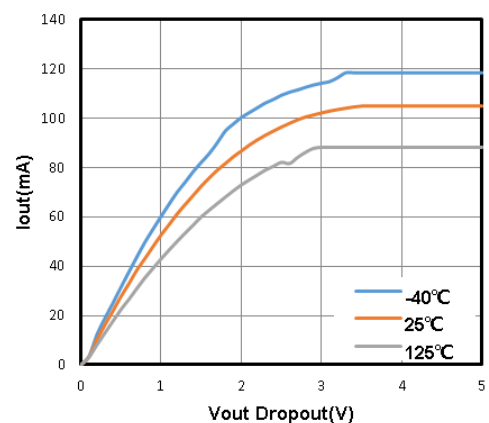


Figure 6. Offset Voltage vs. Common-Mode Voltage


Figure 7. CMRR vs. Frequency

Figure 8. CMRR vs. Temperature

Figure 9. PSRR vs. Frequency

Figure 10. PSRR vs. Temperature

Figure 11. Input Voltage Noise Spectral Density

Figure 12. 0.1-Hz to 10-Hz Input Voltage Noise


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. Negative Output Swing vs. Load Current

Figure 18. Positive Output Swing vs. Load Current

Detailed Description

Functional Block Diagram

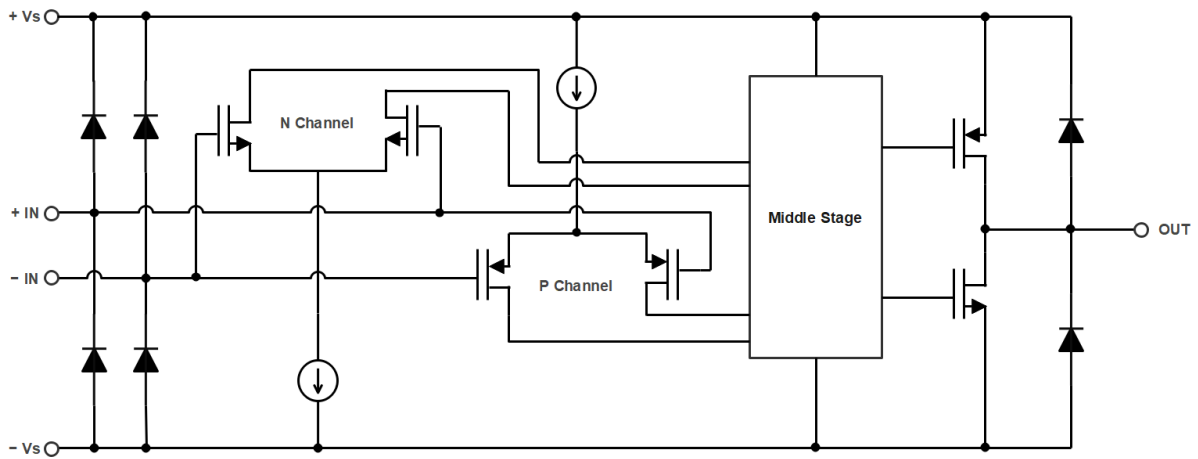


Figure 19. Functional Block Diagram

Application and Implementation

Note

Information in the following application 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.

Application Information

Low Supply Voltage and Low Power Consumption

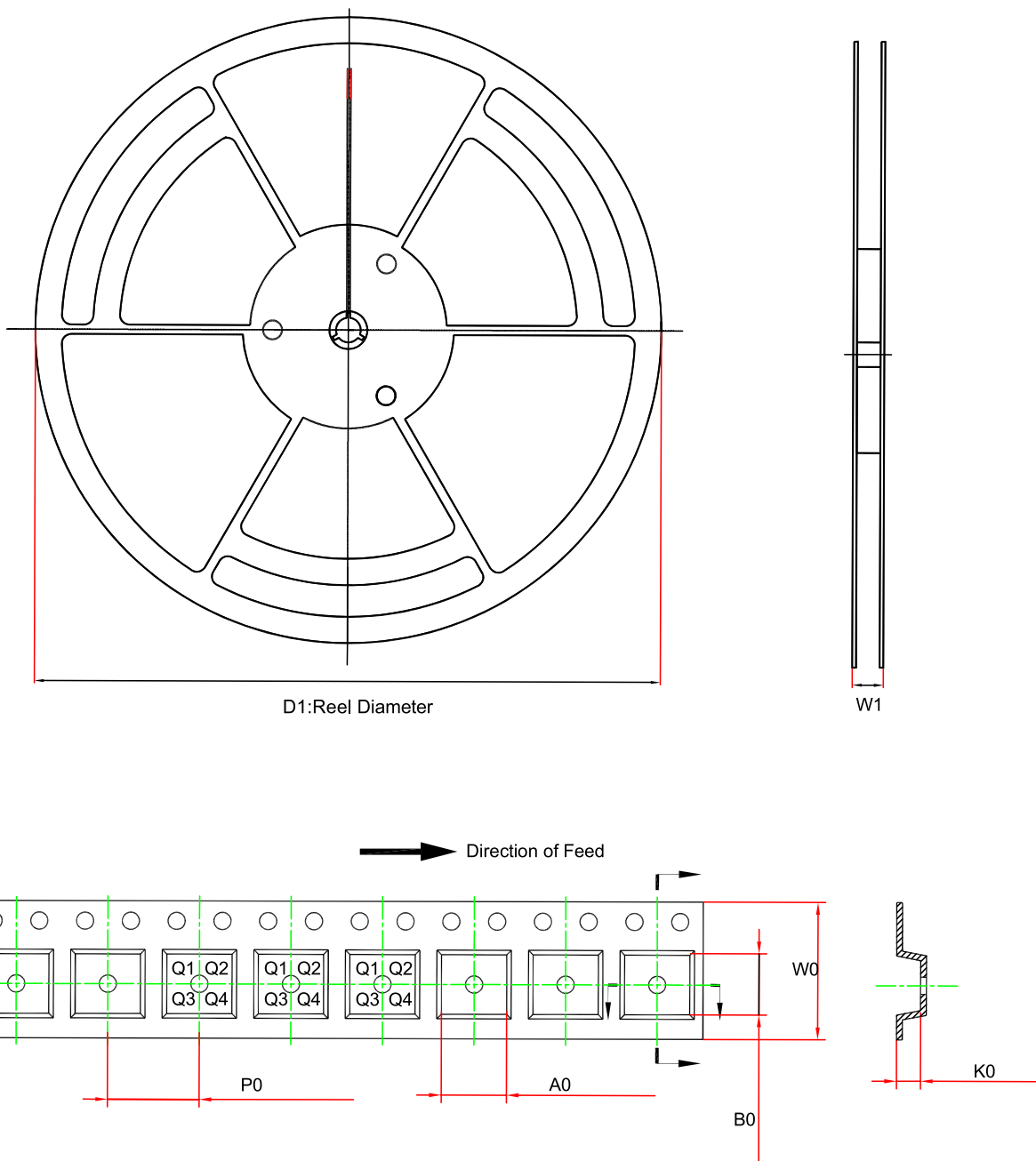
The TP156xAL1 family of operational amplifiers can operate with power supply voltages ranging from 2.5 V to 6 V. Each amplifier draws only 600- μ A quiescent current. The low-supply voltage capability and low-supply current are ideal for portable applications demanding high capacitive load driving capability and stable wide bandwidth. The TP156xAL1 family is optimized for wide bandwidth and low-power applications. They have an industry leading high GBWP to power ratio and are unity gain stable for any capacitive load. When the load capacitance increases, the increased capacitance at the output pushed the non-dominant pole to lower frequency in the open loop frequency response, lowering the phase and gain margin. Higher gain configurations tend to have better capacitive drive capability than lower gain configurations due to lower closed loop bandwidth and hence higher phase margin.

Ground Sensing and Rail-to-Rail Output

The TP156xAL1 family has excellent output drive capability, delivering over 100 mA of output drive current. The output stage is a rail-to-rail topology that is capable of swinging to within 10 mV of either rail. Since the inputs can go 300 mV beyond either rail, the op-amp can easily perform 'true ground' sensing.

The maximum output current is a function of total supply voltage. As the supply voltage to the amplifier increases, the output current capability also increases. Attention must be paid to keep the junction temperature of the IC below 150°C when the output is in continuous short-circuit. The output of the amplifier has reverse-biased ESD diodes connected to each supply. The output should not be forced more than 0.5 V beyond either supply, otherwise the current will flow through these diodes.

Tape and Reel Information



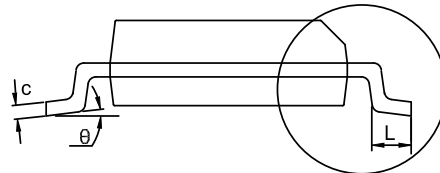
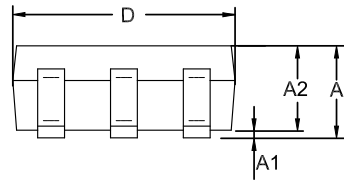
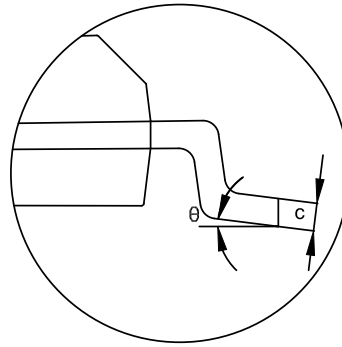
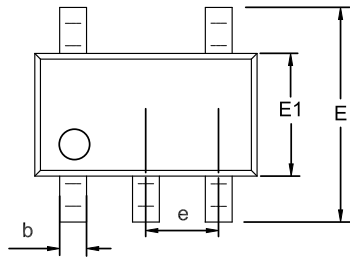
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TP1561AL1-S5TR-S	SOT23-5	180.0	13.1	3.2	3.2	1.4	4.0	8.0	Q3
TP1562AL1-SO1R-S	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TP1562AL1-VS1R-S	MSOP8	330.0	17.6	5.2	3.3	1.5	8.0	12.0	Q1
TP1564AL1-SO2R-S	SOP14	330.0	21.6	6.5	9.0	2.1	8.0	16.0	Q1
TP1564AL1-TS2R-S	TSSOP14	330.0	17.6	6.8	5.5	1.3	8.0	12.0	Q1

Package Outline Dimensions

SOT23-5

Package Outline Dimensions

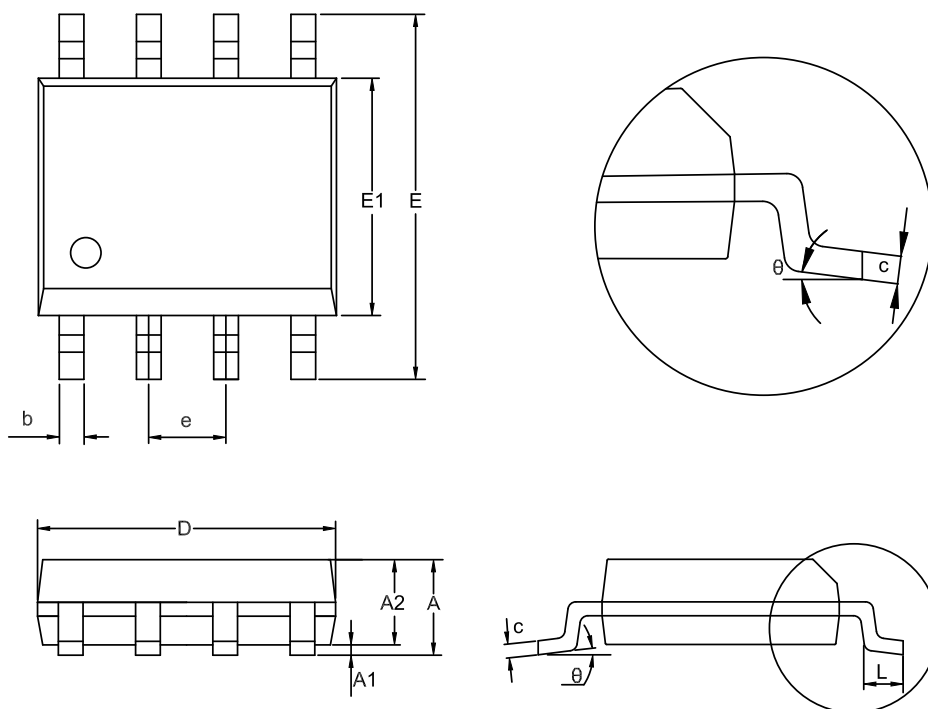
S5T(SOT23-5-A)



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

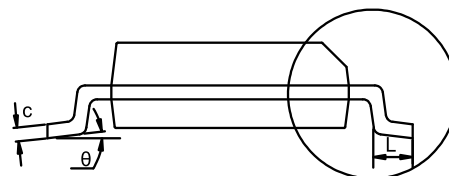
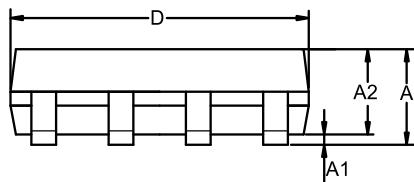
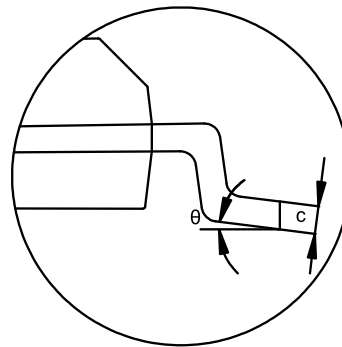
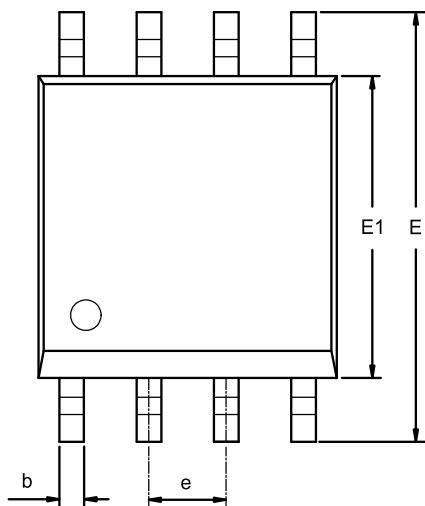
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

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

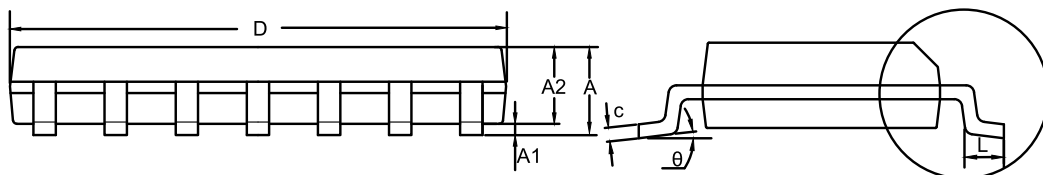
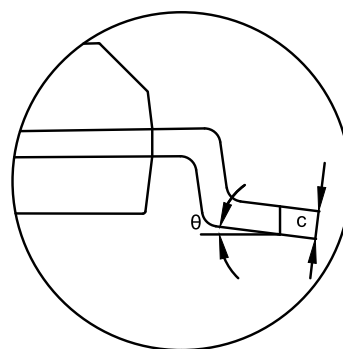
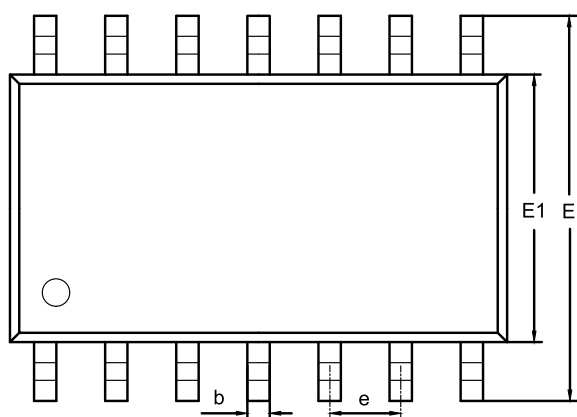
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

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	0.020	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	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

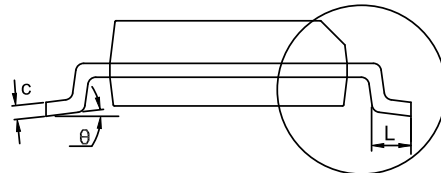
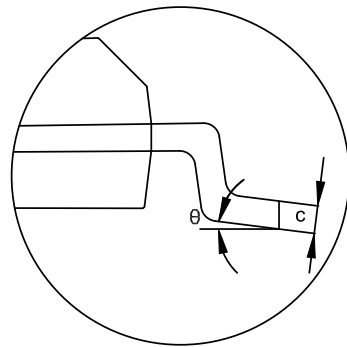
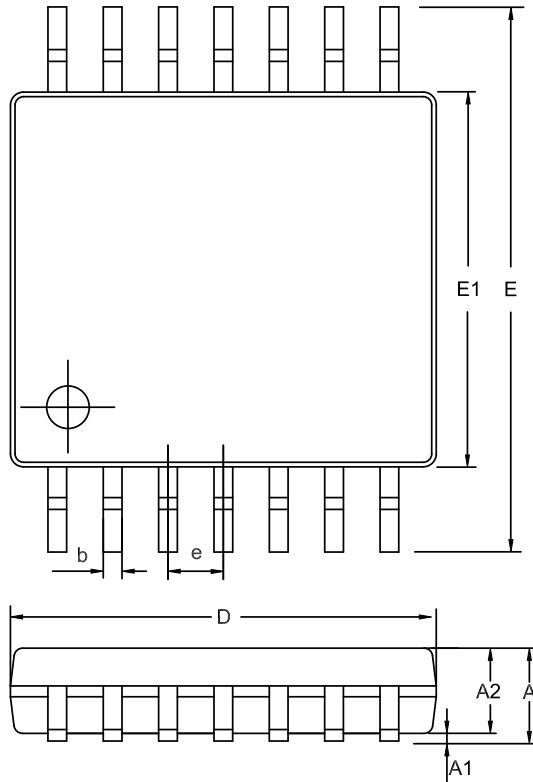
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

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.

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.

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TP1561AL1-S5TR-S	-40 to 125°C	SOT23-5	61S	MSL 3	Tape and Reel, 3000	Green
TP1562AL1-SO1R-S	-40 to 125°C	SOP8	1562S	MSL 1	Tape and Reel, 4000	Green
TP1562AL1-VS1R-S	-40 to 125°C	MSOP8	1562S	MSL 1	Tape and Reel, 3000	Green
TP1564AL1-SO2R-S	-40 to 125°C	SOP14	1564S	MSL 1	Tape and Reel, 2500	Green
TP1564AL1-TS2R-S	-40 to 125°C	TSSOP14	1564S	MSL 3	Tape and Reel, 3000	Green

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

IMPORTANT NOTICE AND DISCLAIMER

Copyright© 3PEAK 2012-2024. All rights reserved.

Trademarks. Any of the 思瑞浦 or 3PEAK trade names, trademarks, graphic marks, and domain names contained in this document /material are the property of 3PEAK. You may NOT reproduce, modify, publish, transmit or distribute any Trademark without the prior written consent of 3PEAK.

Performance Information. Performance tests or performance range contained in this document/material are either results of design simulation or actual tests conducted under designated testing environment. Any variation in testing environment or simulation environment, including but not limited to testing method, testing process or testing temperature, may affect actual performance of the product.

Disclaimer. 3PEAK provides technical and reliability data (including data sheets), design resources (including reference designs), application or other design recommendations, networking tools, security information and other resources "As Is". 3PEAK makes no warranty as to the absence of defects, and makes no warranties of any kind, express or implied, including without limitation, implied warranties as to merchantability, fitness for a particular purpose or non-infringement of any third-party's intellectual property rights. Unless otherwise specified in writing, products supplied by 3PEAK are not designed to be used in any life-threatening scenarios, including critical medical applications, automotive safety-critical systems, aviation, aerospace, or any situations where failure could result in bodily harm, loss of life, or significant property damage. 3PEAK disclaims all liability for any such unauthorized use.