

## Features

- Supply Voltage: 4.5 V to 36 V
- Offset Voltage: ±150 μV (Max)
- Differential Input Voltage Range to Supply Rail, Can Work as Comparator
- Input Rail to -V<sub>S</sub>, Rail-to-Rail Output
- Bandwidth: 7 MHz
- Slew Rate: 20 V/μs
- Excellent EMI Suppress Performance: 45 dB at 1 GHz
- Over-Temperature Protection
- Low Noise: 25 nV/√Hz at 1 kHz
- 4-kV HBM, 2-kV CDM, 400-mA Latch Up
- Operating Temperature Range: -40°C to 125°C

## Applications

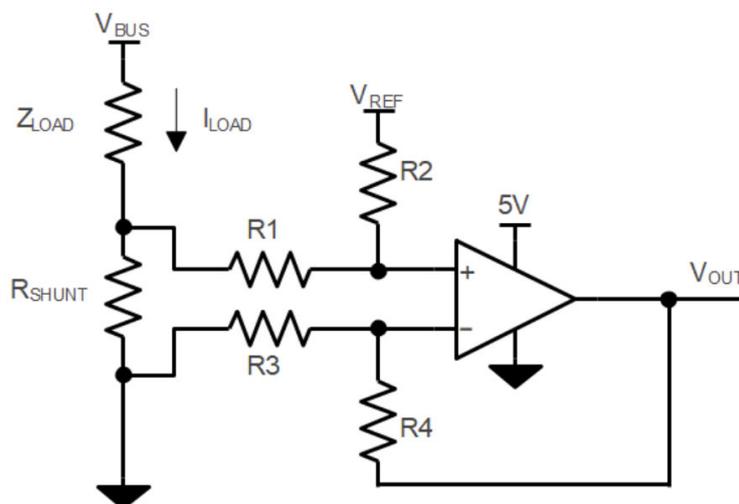
- Instrumentation
- Active Filters, ASIC Input or Output Amplifier
- Sensor Interface
- Motor Control
- Industrial Control

## Description

The TP128x is a series of the newest high supply voltage amplifiers with low offset, low power, and stable high-frequency response. The series incorporates 3PEAK's proprietary and patented design techniques to achieve excellent AC performance with 7-MHz bandwidth, 20-V/μs slew rate, and low distortion while drawing only 1600 μA of quiescent current per amplifier. The input common-mode voltage range extends to -V<sub>S</sub>, and the outputs swing rail-to-rail. The TP128x series can be used as plug-in replacements for commercially available op amps to reduce power, extend input/output range, and improve performance.

The TP128x has an over-temperature protection to guarantee chip safety. The outputs of TP128x enter high impedance when the die temperature reaches around 170°C, and recover the function when the die temperature is down to around 150°C.

## Typical Application Circuit



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

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

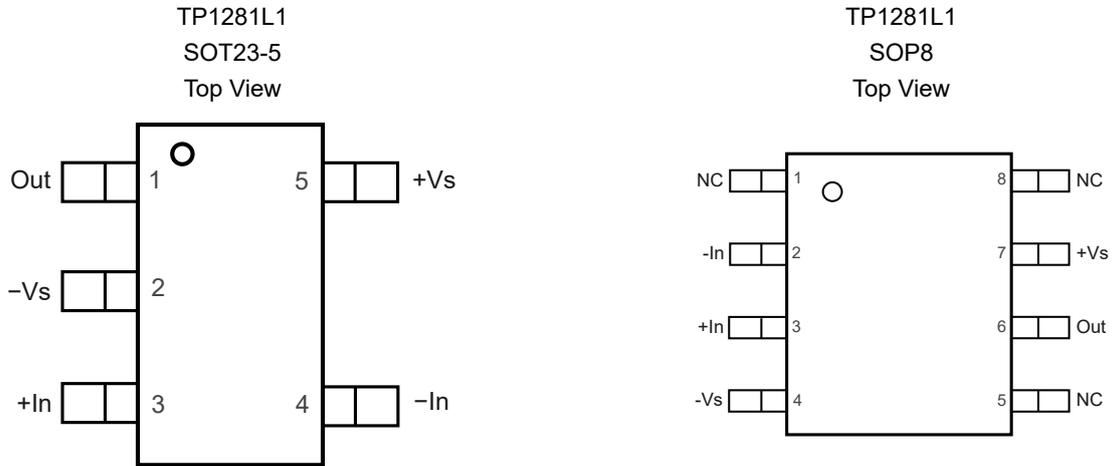
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## Revision History

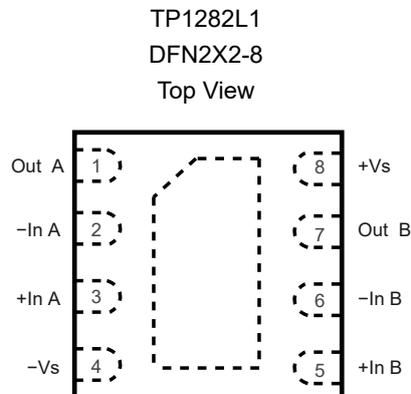
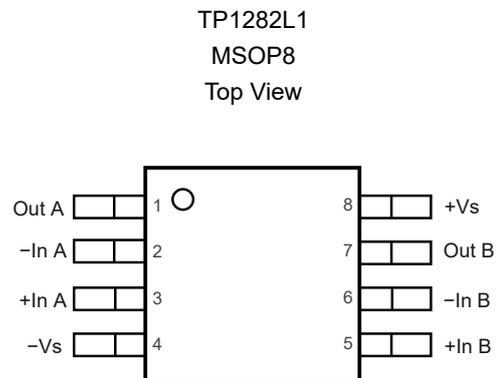
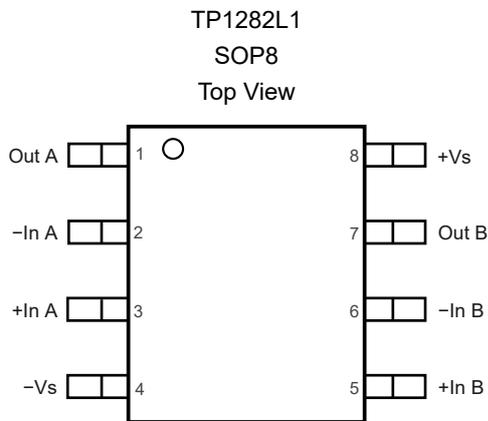
Date	Revision	Notes
2018-10-20	Rev.Pre.0	Initial version.
2021-03-10	Rev.A.0	Added a new part number: TP1284-TR.
2022-04-29	Rev.A.1	Updated Order Information.
2022-07-17	Rev.A.2	Removed TP1284L1-SR. Added TP1284-SR.
2024-12-30	Rev.A.3	The following updates are all about the new datasheet formats or typos, and the actual product remains unchanged. <ul style="list-style-type: none"><li>• Updated to a new datasheet format.</li><li>• Updated to a new format of Package Outline Dimensions.</li><li>• Updated the Tape and Reel Information.</li><li>• Added thermal pad PIN description of TP1282L1-FR.</li></ul>

### Pin Configuration and Functions

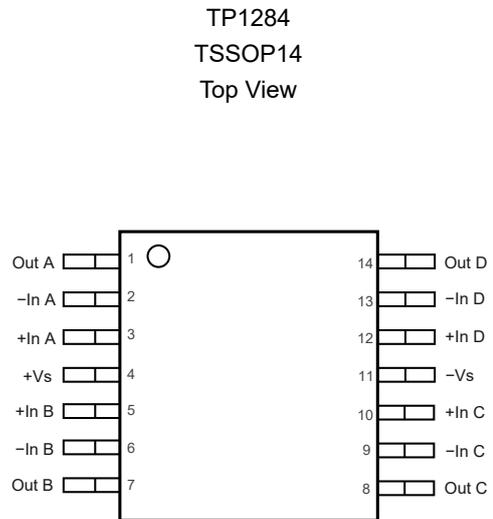
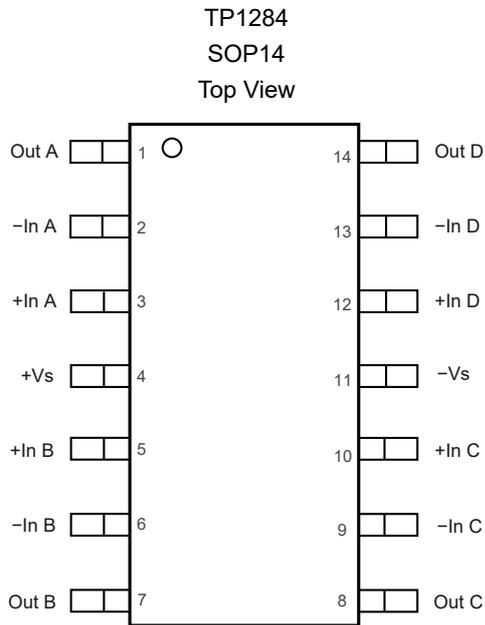


**Table 1. Pin Functions: TP1281L1**

Pin No.		Name	I/O	Description
SOT23-5	SOP8			
1	6	Out	O	Output
2	4	-Vs		Negative power supply
3	3	+In	I	Non-inverting input
4	2	-In	I	Inverting input
5	7	+Vs		Positive power supply
	1	NC		Not connected
	5	NC		Not connected
	8	NC		Not connected


**Table 2. Pin Functions: TP1282L1**

Pin No.	Name	I/O	Description
1	Out A	O	Output
2	-In A	I	Inverting input
3	+In A	I	Non-inverting input
4	-Vs		Negative power supply
5	+In B	I	Non-inverting input
6	-In B	I	Inverting input
7	Out B	O	Output
8	+Vs		Positive power supply
	Thermal Pad		The underneath exposed pad for thermal enhancement. Connect the thermal pad to -Vs plane for better thermal performance of the device.


**Table 3. Pin Functions: TP1284**

Pin No.	Name	I/O	Description
1	Out A	O	Output
2	-In A	I	Inverting input
3	+In A	I	Non-inverting input
4	+Vs		Positive power supply
5	+In B	I	Non-inverting input
6	-In B	I	Inverting input
7	Out B	O	Output
8	Out C	O	Output
9	-In C	I	Inverting input
10	+In C	I	Non-inverting input
11	-Vs		Negative power supply
12	+In D	I	Non-inverting input
13	-In D	I	Inverting input
14	Out D	O	Output

## Specifications

### Absolute Maximum Ratings <sup>(1)</sup>

	Parameter	Min	Max	Unit
	Supply Voltage: (+V <sub>S</sub> ) – (–V <sub>S</sub> )		40	V
	Input Voltage	(–V <sub>S</sub> ) – 0.3	(+V <sub>S</sub> ) + 0.3	V
	Differential Input Voltage	(–V <sub>S</sub> ) – (+V <sub>S</sub> )	(+V <sub>S</sub> ) – (–V <sub>S</sub> )	V
	Input Current: +IN, –IN <sup>(2)</sup>	–10	10	mA
	Output Short-Circuit Duration <sup>(3)</sup>		Infinite	
T <sub>J</sub>	Maximum Junction Temperature		150	°C
T <sub>A</sub>	Operating Temperature Range	–40	125	°C
T <sub>STG</sub>	Storage Temperature Range	–65	150	°C
T <sub>L</sub>	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 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.
- (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 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 <sup>(1)</sup>	4	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 <sup>(2)</sup>	2	kV
LU	Latch Up	JESD 78, 25°C	400	mA
		JESD 78, 125°C	300	mA

- (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	$\theta_{JA}$	$\theta_{JC}$	Unit
SOT23-5	250	81	$^{\circ}\text{C}/\text{W}$
SOP8	158	43	$^{\circ}\text{C}/\text{W}$
MSOP8	210	45	$^{\circ}\text{C}/\text{W}$
DFN2X2-8	100	60	$^{\circ}\text{C}/\text{W}$
SOP14	120	36	$^{\circ}\text{C}/\text{W}$
TSSOP14	180	35	$^{\circ}\text{C}/\text{W}$

**Electrical Characteristics**

 All test conditions:  $V_S = 30\text{ V}$ ,  $T_A = 25^\circ\text{C}$ ,  $R_L = 10\text{ k}\Omega$ , unless otherwise noted.

Symbol	Parameter	Conditions	$T_A$	Min	Typ	Max	Unit
<b>Power Supply</b>							
$V_S$	Supply Voltage Range			4.5		36	V
$I_Q$	Quiescent Current per Amplifier	$V_S = 30\text{ V}$ , TP1281			1.5	2	mA
			$-40^\circ\text{C}$ to $125^\circ\text{C}$			3	mA
		$V_S = 30\text{ V}$ , TP1282/TP1284			1	1.6	mA
			$-40^\circ\text{C}$ to $125^\circ\text{C}$			2.5	mA
PSRR	Power Supply Rejection Ratio	$V_S = 4.5\text{ V}$ to $36\text{ V}$		105	130		dB
			$-40^\circ\text{C}$ to $125^\circ\text{C}$	100			dB
<b>Input Characteristics</b>							
$V_{OS}$	Input Offset Voltage	$V_S = 30\text{ V}$ , $V_{CM} = 15\text{ V}$ , TP1281/TP1282		-100	50	100	$\mu\text{V}$
			$-40^\circ\text{C}$ to $85^\circ\text{C}$	-400		400	$\mu\text{V}$
			$-40^\circ\text{C}$ to $125^\circ\text{C}$	-600		600	$\mu\text{V}$
		$V_S = 25\text{ V}$ , $V_{CM} = 12.5\text{ V}$ , TP1281/TP1282		-100	50	100	$\mu\text{V}$
			$-40^\circ\text{C}$ to $85^\circ\text{C}$	-400		400	$\mu\text{V}$
			$-40^\circ\text{C}$ to $125^\circ\text{C}$	-600		600	$\mu\text{V}$
$V_S = 5\text{ V}$ , $V_{CM} = 2.5\text{ V}$ , TP1281/TP1282		-150	50	150	$\mu\text{V}$		
	$-40^\circ\text{C}$ to $85^\circ\text{C}$	-500		500	$\mu\text{V}$		
	$-40^\circ\text{C}$ to $125^\circ\text{C}$	-600		600	$\mu\text{V}$		
$V_{OS}$	Input Offset Voltage	$V_S = 30\text{ V}$ , $V_{CM} = 15\text{ V}$ , TP1284		-150	50	150	$\mu\text{V}$
			$-40^\circ\text{C}$ to $85^\circ\text{C}$	-450		450	$\mu\text{V}$
			$-40^\circ\text{C}$ to $125^\circ\text{C}$	-650		650	$\mu\text{V}$
		$V_S = 25\text{ V}$ , $V_{CM} = 12.5\text{ V}$ , TP1284		-150	50	150	$\mu\text{V}$
			$-40^\circ\text{C}$ to $85^\circ\text{C}$	-450		450	$\mu\text{V}$
			$-40^\circ\text{C}$ to $125^\circ\text{C}$	-650		650	$\mu\text{V}$
$V_S = 5\text{ V}$ , $V_{CM} = 2.5\text{ V}$ , TP1284		-200	50	200	$\mu\text{V}$		
	$-40^\circ\text{C}$ to $85^\circ\text{C}$	-550		550	$\mu\text{V}$		
	$-40^\circ\text{C}$ to $125^\circ\text{C}$	-650		650	$\mu\text{V}$		
$V_{OS\ TC}$	Input Offset Voltage Drift		$-40^\circ\text{C}$ to $125^\circ\text{C}$		1		$\mu\text{V}/^\circ\text{C}$
$I_B$	Input Bias Current				25		pA
		$-40^\circ\text{C}$ to $85^\circ\text{C}$			80		pA
		$-40^\circ\text{C}$ to $125^\circ\text{C}$			1000		pA
$I_{OS}$	Input Offset Current				25		pA
$I_{IN}$	Differential Input Current	$V_S = 36\text{ V}$ , $V_{ID} = 36\text{ V}$			10	100	nA
			$-40^\circ\text{C}$ to $125^\circ\text{C}$			100	300

Symbol	Parameter	Conditions	T <sub>A</sub>	Min	Typ	Max	Unit	
C <sub>IN</sub>	Input Capacitance	Differential mode			5		pF	
		Common mode			2.5		pF	
A <sub>V</sub>	Open-Loop Voltage Gain	V <sub>S</sub> = 30 V, V <sub>OUT</sub> = 0.5 V to 29.5 V		120	130		dB	
			-40°C to 125°C	105			dB	
V <sub>CMR</sub>	Common-Mode Input Voltage Range			(-V <sub>S</sub> )		(+V <sub>S</sub> ) - 1.5	V	
CMRR	Common-Mode Rejection Ratio	V <sub>CM</sub> = 0.5 V to 28.5 V		100	125		dB	
			-40°C to 125°C	95			dB	
<b>Output Characteristics</b>								
V <sub>OH</sub>	Output Swing from Positive Rail	R <sub>LOAD</sub> = 100 k $\Omega$ to V <sub>S</sub> / 2			5	15	mV	
			-40°C to 85°C				30	mV
			-40°C to 125°C				40	mV
		R <sub>LOAD</sub> = 10 k $\Omega$ to V <sub>S</sub> / 2			50	80	mV	
			-40°C to 85°C				120	mV
			-40°C to 125°C				130	mV
V <sub>OL</sub>	Output Swing from Negative Rail	R <sub>LOAD</sub> = 100 k $\Omega$ to V <sub>S</sub> / 2			5	10	mV	
			-40°C to 85°C				20	mV
			-40°C to 125°C				25	mV
		R <sub>LOAD</sub> = 10 k $\Omega$ to V <sub>S</sub> / 2			40	50	mV	
			-40°C to 85°C				80	mV
			-40°C to 125°C				100	mV
I <sub>SC</sub>	Output Short-Circuit Current	Source current		20	32		mA	
		Sink current		15	25		mA	
<b>AC Specifications</b>								
GBW	Gain-Bandwidth Product				7		MHz	
SR	Slew Rate	G = 1, 10-V step		13	20		V/ $\mu$ s	
			-40°C to 125°C	10			V/ $\mu$ s	
t <sub>OR</sub>	Overload Recovery				100		ns	
t <sub>S</sub>	Settling Time, 0.1%	G = -1, 10-V step			0.5		$\mu$ s	
	Settling Time, 0.01%				0.8		$\mu$ s	
PM	Phase Margin	V <sub>S</sub> = 36 V, R <sub>L</sub> = 10 k $\Omega$ , C <sub>L</sub> = 100 pF			60		°	
GM	Gain Margin	V <sub>S</sub> = 36 V, R <sub>L</sub> = 10 k $\Omega$ , C <sub>L</sub> = 100 pF			10		dB	

Symbol	Parameter	Conditions	$T_A$	Min	Typ	Max	Unit
<b>Output Characteristics</b>							
$E_N$	Input Voltage Noise	$f = 0.1 \text{ Hz to } 10 \text{ Hz}$			2		$\mu\text{V}_{\text{RMS}}$
$e_N$	Input Voltage Noise Density	$f = 1 \text{ kHz}$			25		$\text{nV}/\sqrt{\text{Hz}}$
$i_N$	Input Current Noise	$f = 1 \text{ kHz}$			2		$\text{fA}/\sqrt{\text{Hz}}$
THD+N	Total Harmonic Distortion and Noise	$f = 1 \text{ kHz}, G = 1, R_L = 10 \text{ k}\Omega,$ $V_{\text{OUT}} = 6 \text{ V}_{\text{RMS}}$			0.0005		%
<b>AC Specifications</b>							
	Thermal Shutdown Temperature				170		$^{\circ}\text{C}$
	Recover Temperature				150		$^{\circ}\text{C}$

Typical Performance Characteristics

All test conditions:  $V_S = \pm 15\text{ V}$ ,  $V_{CM} = 0\text{ V}$ ,  $R_L = 10\text{ k}\Omega$ , unless otherwise specified.

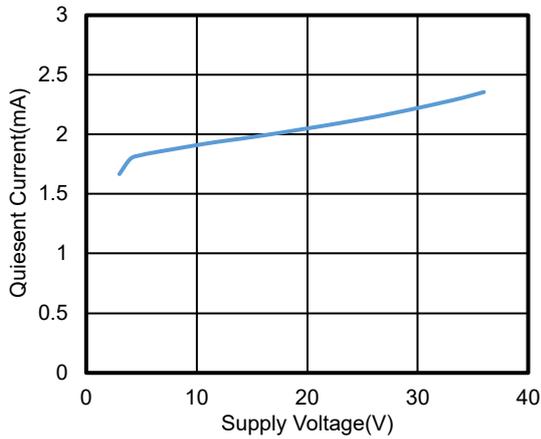


Figure 1. Quiescent Current vs. Supply Voltage, TP1282

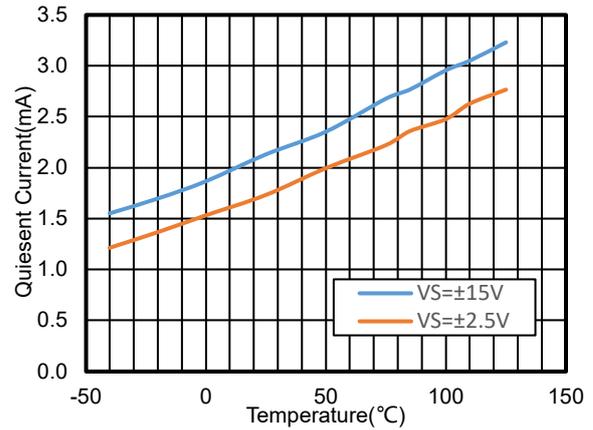


Figure 2. Quiescent Current vs. Temperature, TP1282

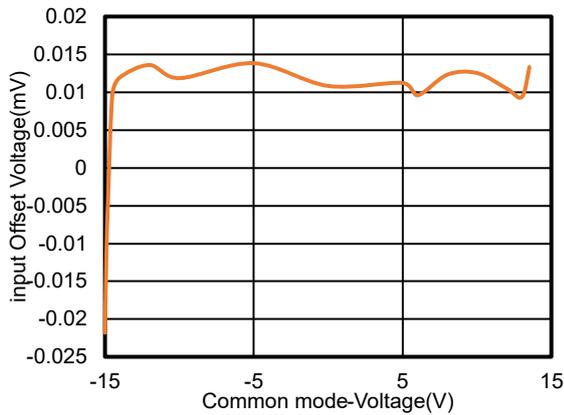


Figure 3. Offset Voltage vs. Common-Mode Voltage

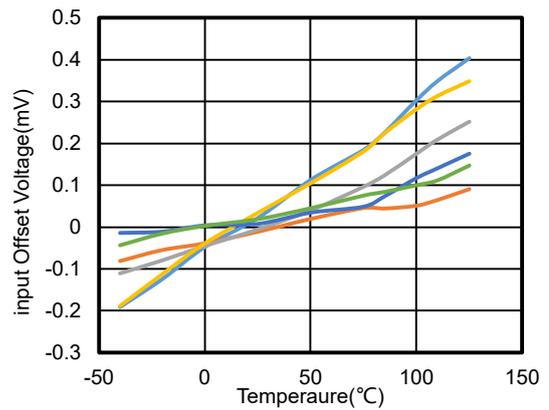


Figure 4.  $V_{OS}$  vs. Temperature

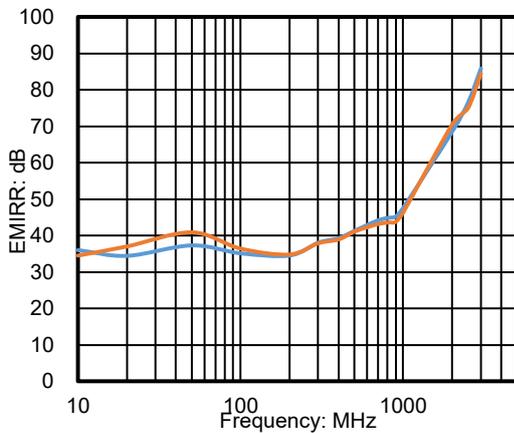


Figure 5. EMIRR vs. Frequency

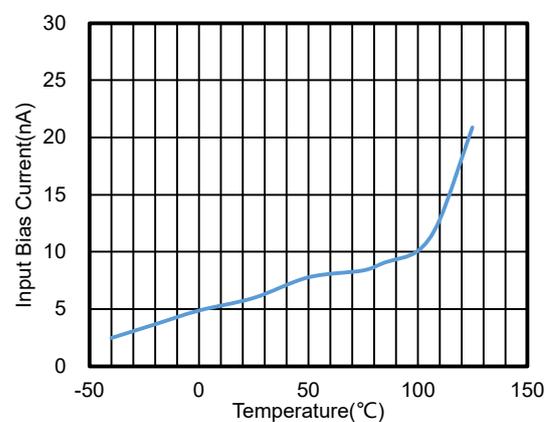


Figure 6. Input Current in Large  $V_{DM}$  vs. Temperature

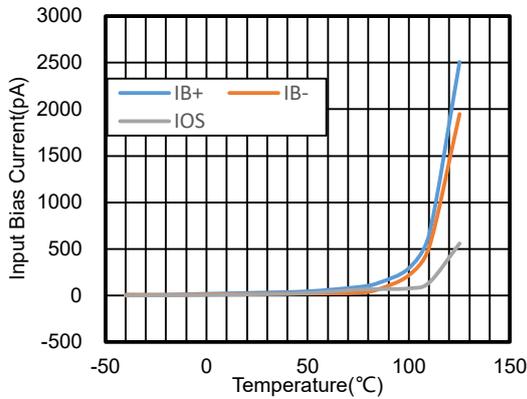


Figure 7.  $I_B$  vs. Temperature, -40 to 125°C

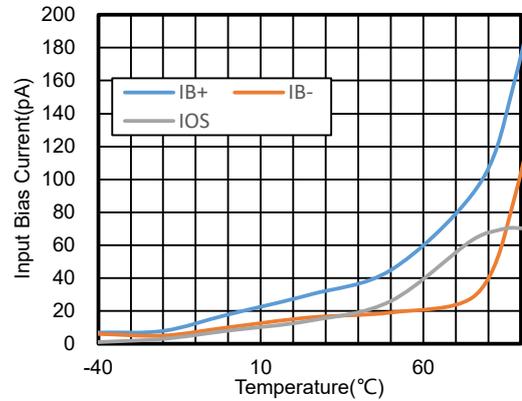


Figure 8.  $I_B$  vs. Temperature, -40 to 90°C

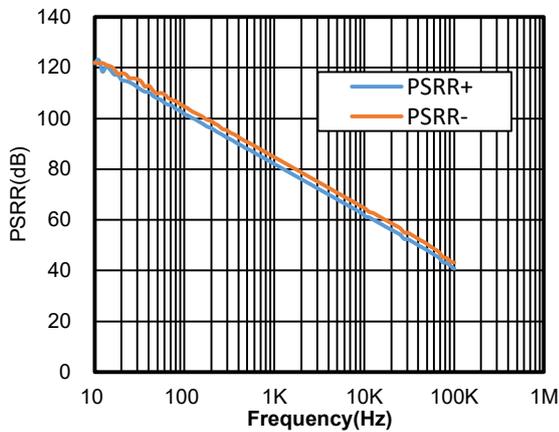


Figure 9. PSRR vs. Frequency

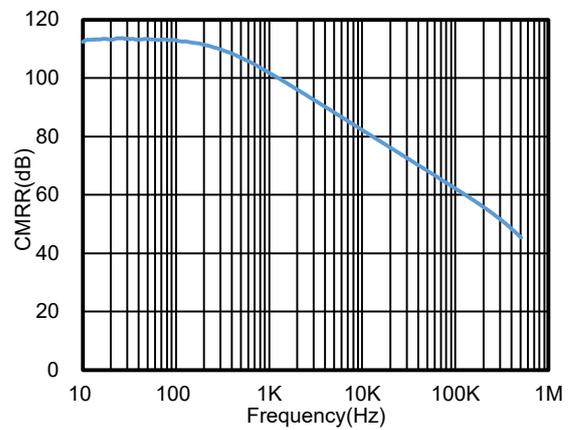


Figure 10. CMRR vs. Frequency

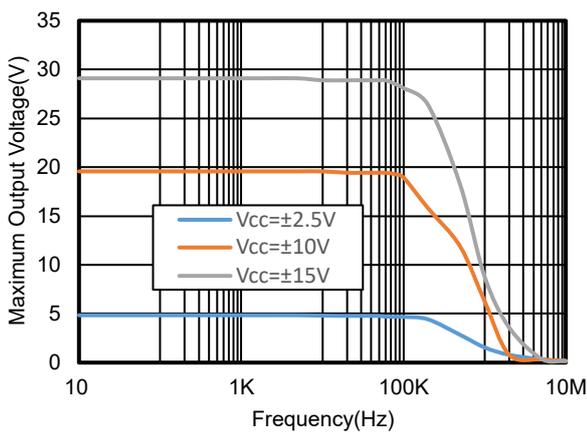
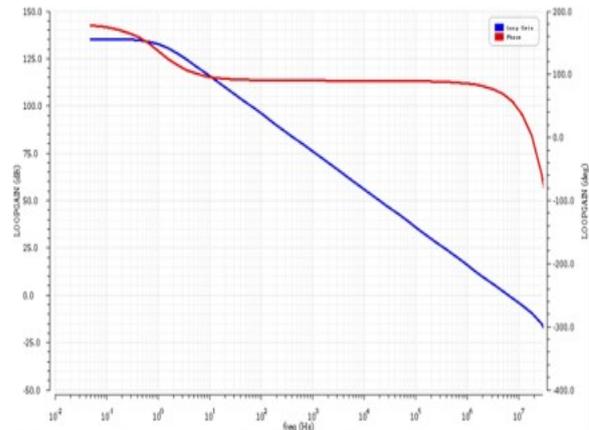


Figure 11. Maximum Output Voltage vs. Frequency



$R_{LOAD} = 10\text{ K}$ ,  $C_{LOAD} = 100\text{ pF}$

Figure 12. Open-Loop Gain and Phase vs. Frequency

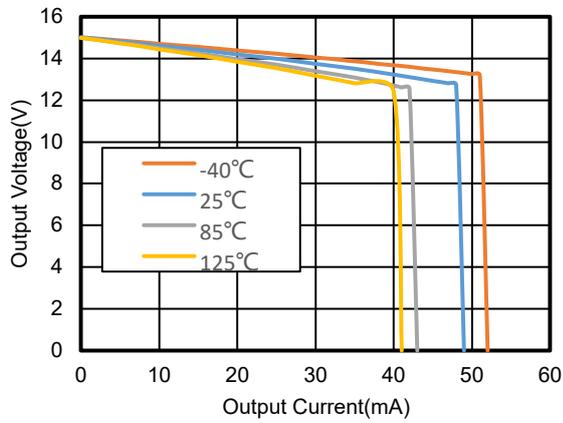


Figure 13. Positive Output Voltage vs. Output Current

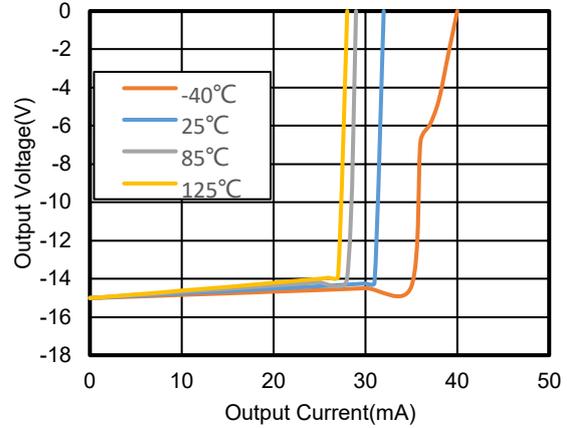


Figure 14. Negative Output Voltage vs. Output Current



Figure 15. Positive Overload Recovery



Figure 16. Negative Overload Recovery



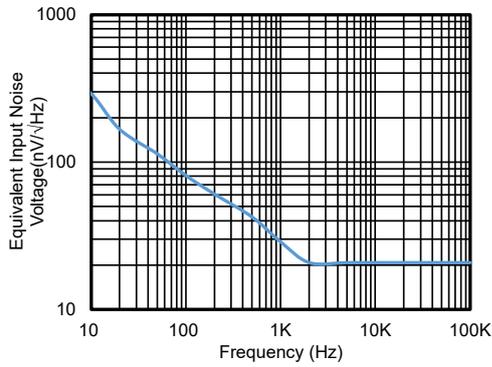
Voltage: 50 mV/div, Time: 1  $\mu$ s/div  
 $R_L = 2\text{ k}\Omega$ ,  $C_L = 100\text{ pF}$ ,  $G = 1$

Figure 17. 100-mV Signal Step Response



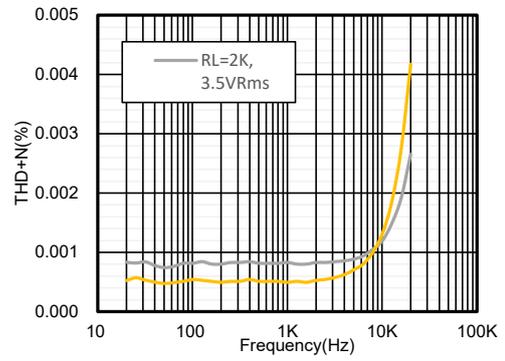
Voltage: 5 V/div, Time: 1  $\mu$ s/div  
 $R_L = 2\text{ k}\Omega$ ,  $C_L = 100\text{ pF}$ ,  $G = 1$

Figure 18. 10-V Signal Step Response



$V_S = \pm 15\text{ V}$ ,  $V_{CM} = 0\text{ V}$

Figure 19. Voltage Noise Spectral Density vs. Frequency



$V_S = \pm 15\text{ V}$ ,  $V_{CM} = 0\text{ V}$

Figure 20. THD+N vs. Frequency

## Detailed Description

### Overview

The TP128x is a series of low-power, rail-to-rail output operational amplifiers. The series operates from 4.5 V to 36 V, is unity-gain stable and designed for a wide range of general-purpose applications.

### Functional Block Diagram

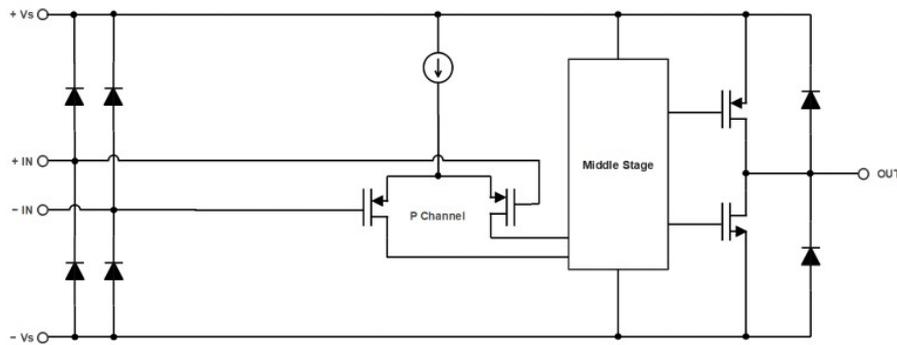


Figure 21. Functional Block Diagram

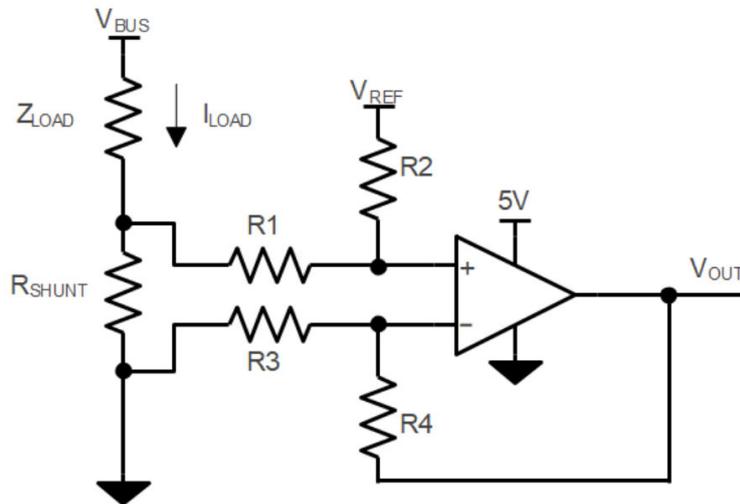
## Application and Implementation

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.

### Typical Application

Figure 22 shows the typical application schematic.

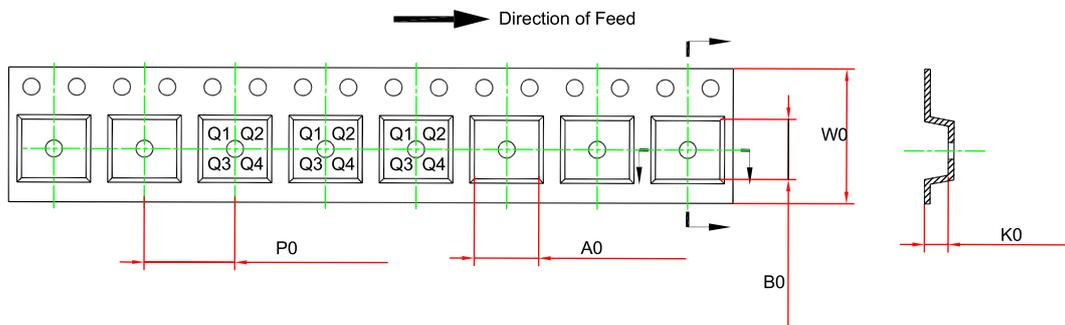
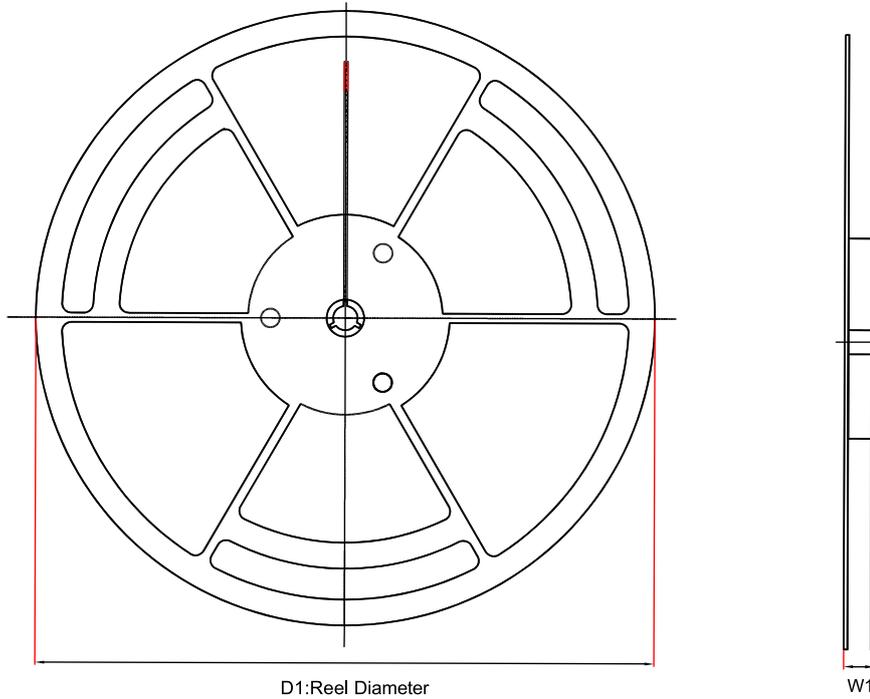


$$V_{OUT} = (I_{LOAD} \times R_{SHUNT}) \times (R2 / R1) + V_{REF}$$

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

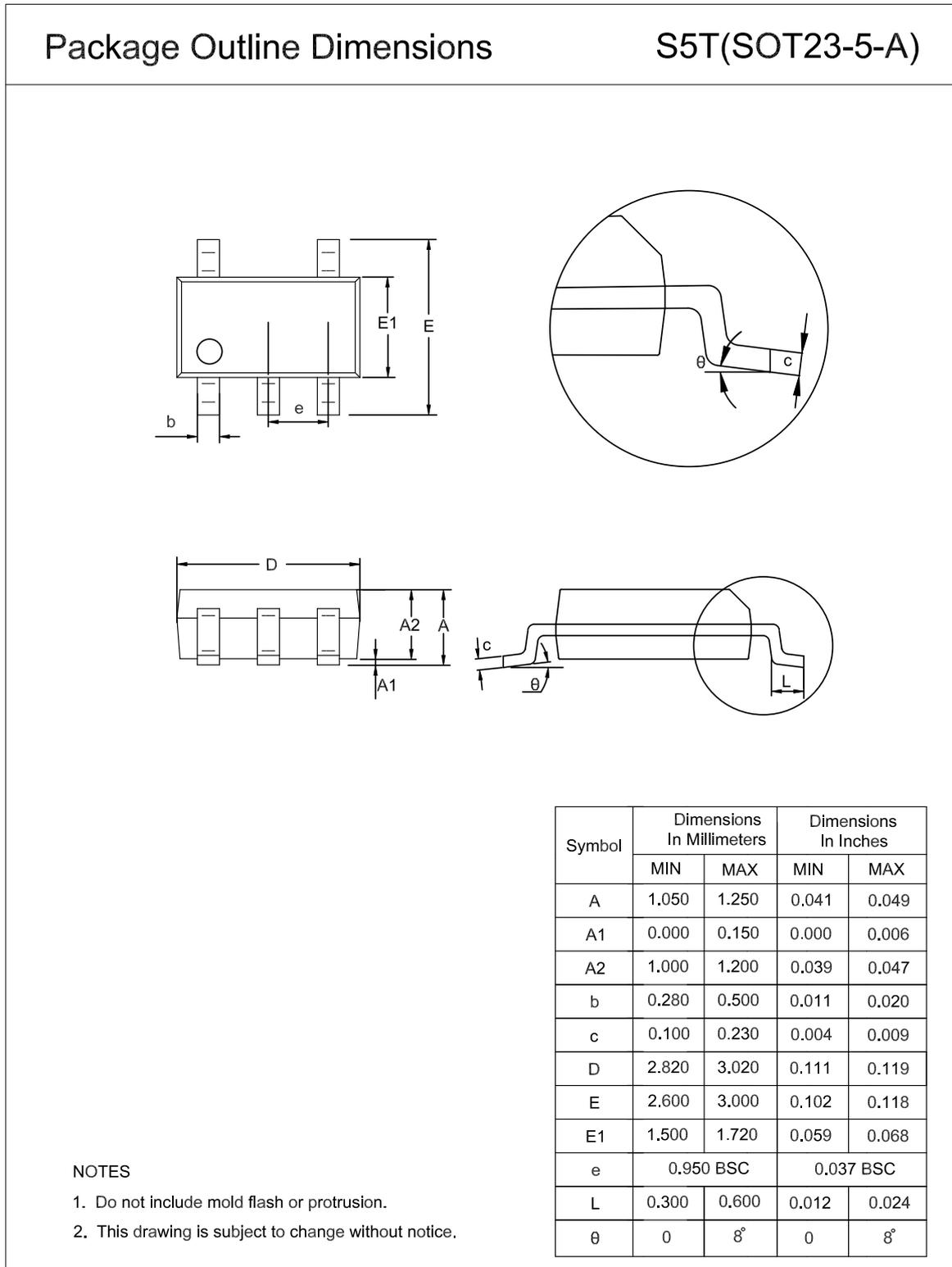
Figure 22. Typical Application Circuit

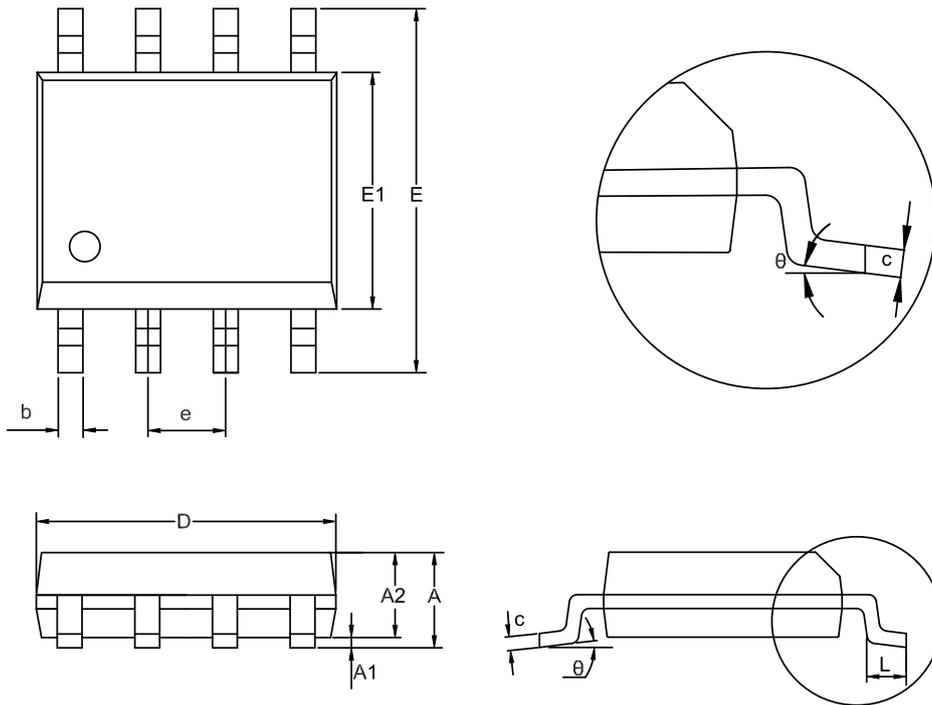
### Tape and Reel Information



Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) <sup>(1)</sup>	B0 (mm) <sup>(1)</sup>	K0 (mm) <sup>(1)</sup>	P0 (mm)	W0 (mm)	Pin1 Quadrant
TP1281L1-TR	SOT23-5	180.0	12.0	3.3	3.25	1.4	4.0	8.0	Q3
TP1282L1-SR	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TP1282L1-VR	MSOP8	330.0	17.6	5.2	3.3	1.5	8.0	12.0	Q1
TP1282L1-FR	DFN2X2-8	180.0	13.1	2.3	2.3	1.1	4.0	8.0	Q1
TP1284-SR	SOP14	330.0	21.6	6.5	9.0	2.1	8.0	16.0	Q1
TP1284-TR	TSSOP14	330.0	17.6	6.8	5.4	1.2	8.0	12.0	Q1

(1) The value is for reference only. Contact the 3PEAK factory for more information.

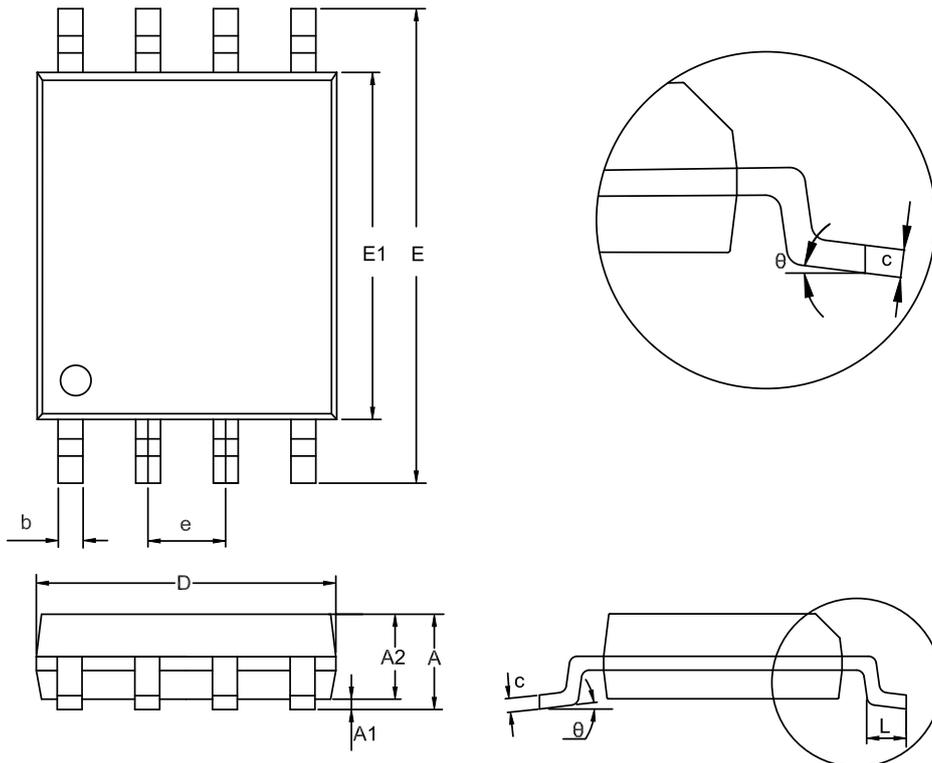
**Package Outline Dimensions**
**SOT23-5**


**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
$\theta$	0	8°	0	8°

**NOTES**

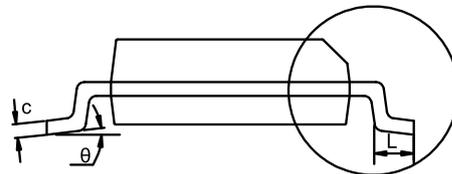
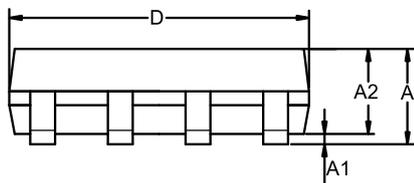
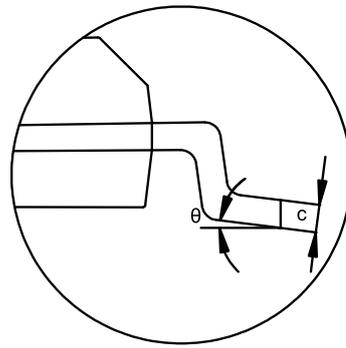
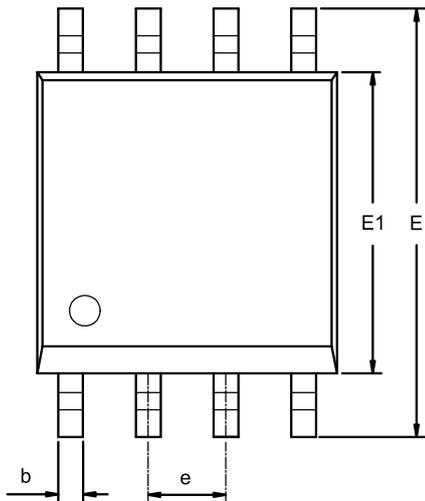
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

**TSSOP8**
**Package Outline Dimensions**
**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
theta	0	8°	0	8°

**NOTES**

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

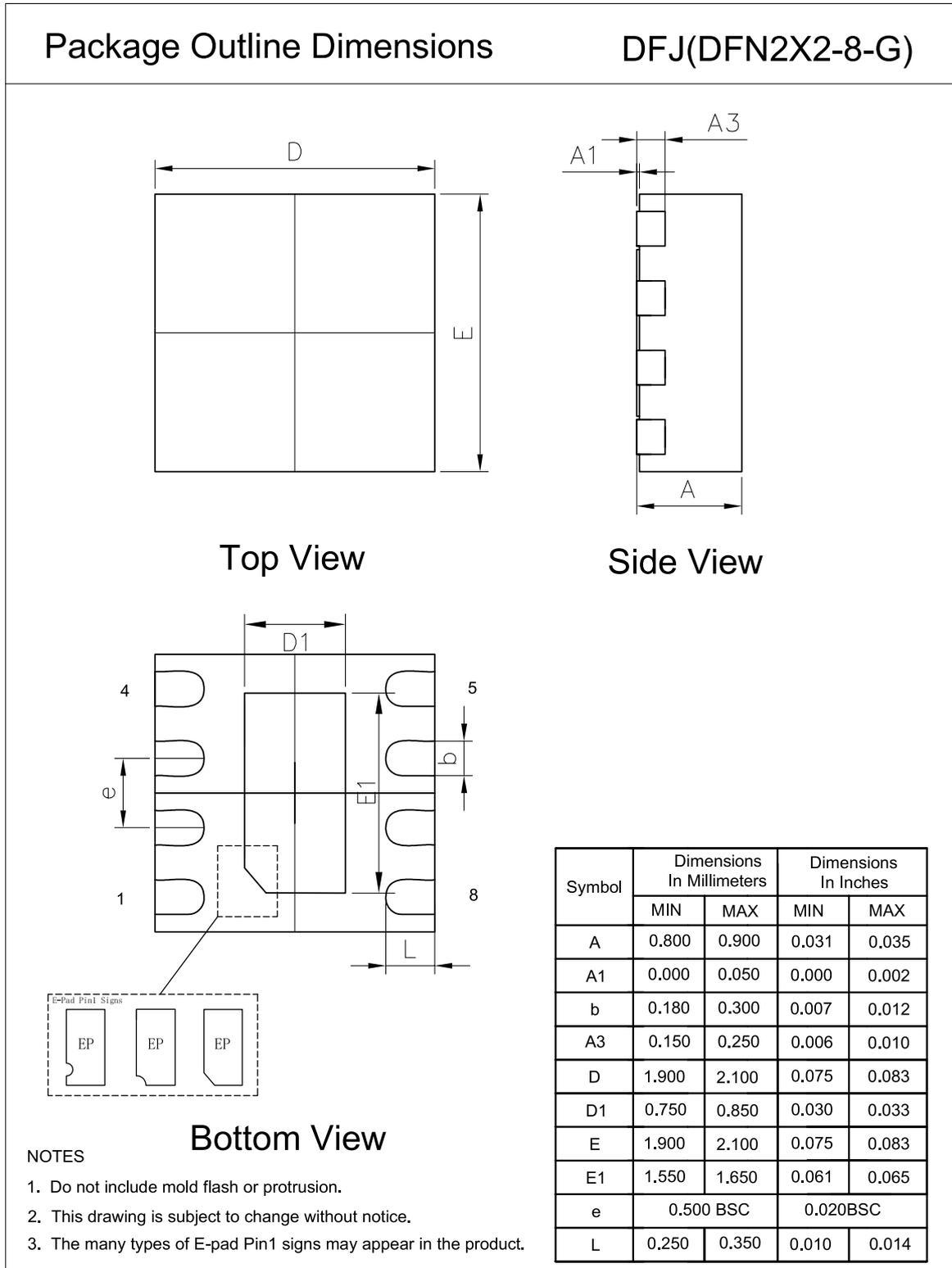
**MSOP8**
**Package Outline Dimensions**
**VS1(MSOP-8-A)**


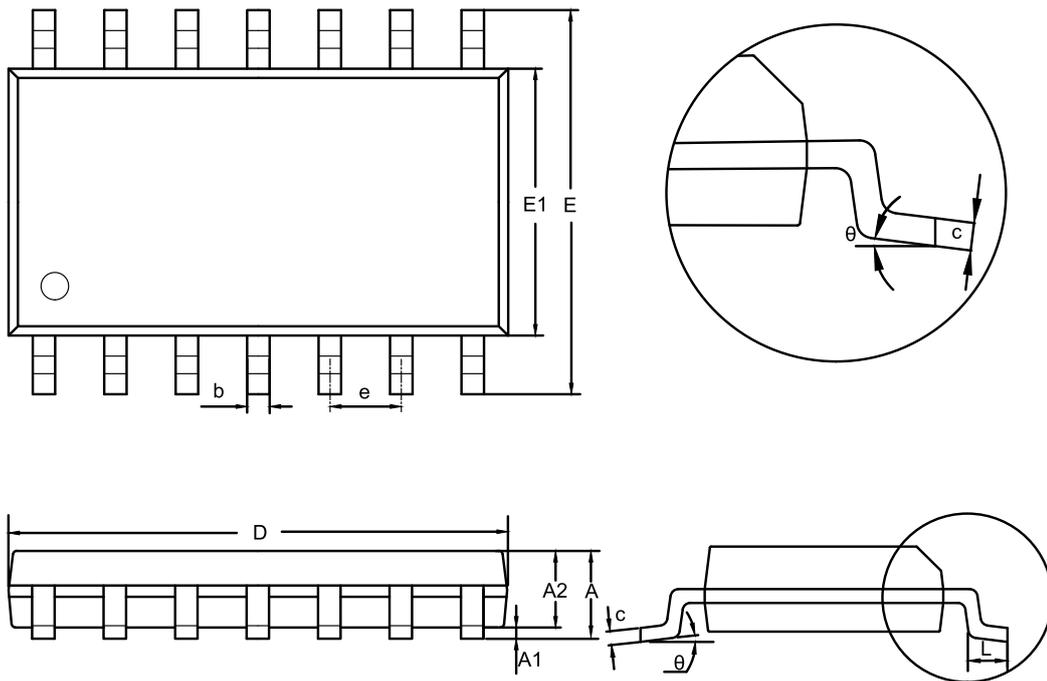
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.650 BSC		0.026 BSC	
L	0.400	0.800	0.016	0.031
$\theta$	0	8°	0	8°

**NOTES**

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

DFN2X2-8



**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
$\theta$	0	8°	0	8°

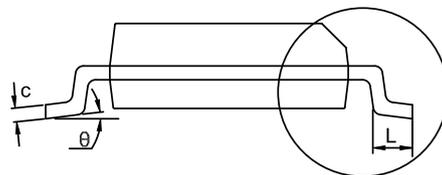
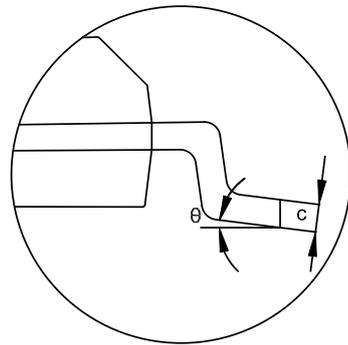
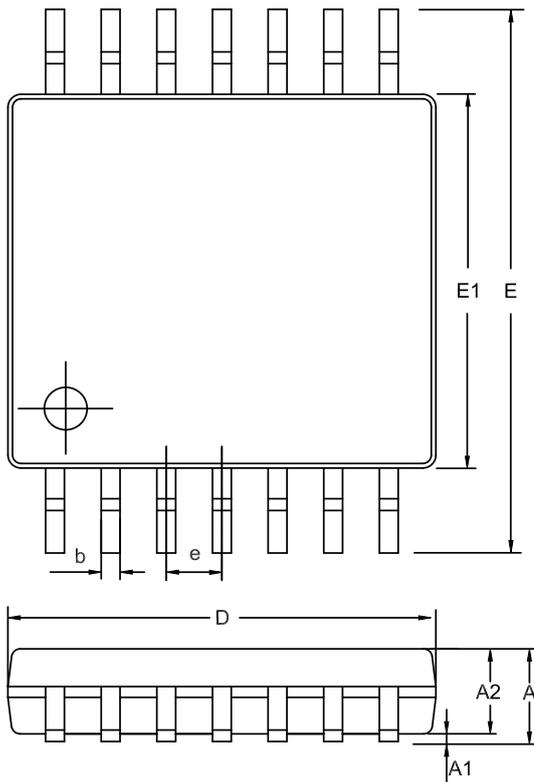
**NOTES**

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
$\theta$	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
TP1281L1-SR	-40 to 125°C	SOP8	1281	1	Tape and Reel, 4000	Green
TP1281L1-TR	-40 to 125°C	SOT23-5	128	1	Tape and Reel, 3000	Green
TP1282L1-SR	-40 to 125°C	SOP8	1282	1	Tape and Reel, 4000	Green
TP1282L1-VR	-40 to 125°C	MSOP8	1282	1	Tape and Reel, 3000	Green
TP1282L1-FR <sup>(1)</sup>	-40 to 125°C	DFN2X2-8	128	1	Tape and Reel, 3000	Green
TP1284-SR	-40 to 125°C	SOP14	1284	3	Tape and Reel, 2500	Green
TP1284-TR	-40 to 125°C	TSSOP14	1284	3	Tape and Reel, 3000	Green

(1) For future products, contact 3PEAK factory for more information and samples.

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

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