36-V, 7-MHz, 20-V/μs, Operational Amplifiers

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 $-V_S$, 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/$\sqrt{Hz}$ at 1 kHz
- 4-kV HBM, 2-kV CDM, 400-mA Latch Up
- Operating Temperature Range: –40°C to 125°C

Applications

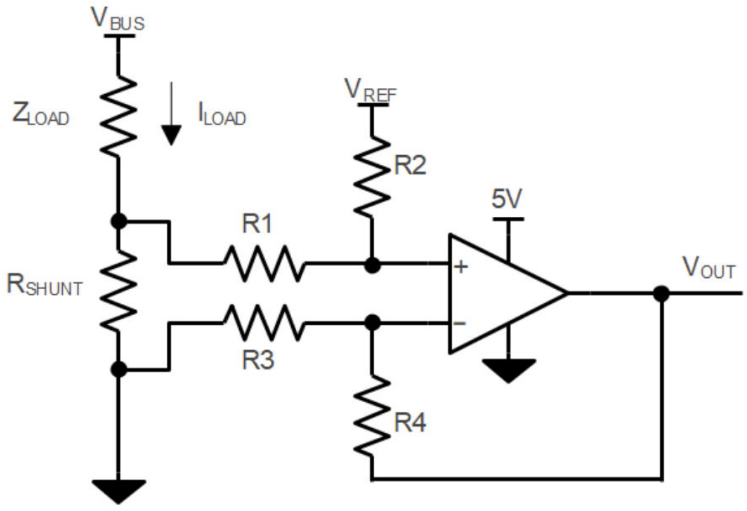
- Instrumentation
- Active Filters, ASIC Input or Output Amplifier
- Sensor Interface
- Motor Control
- Industrial Control

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 $-V_S$, 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 impendence 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



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

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

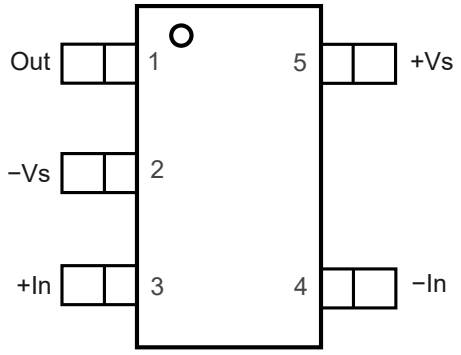
Table of Contents

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. • Updated to a new datasheet format. • Updated to a new format of Package Outline Dimensions. • Updated the Tape and Reel Information. • Added thermal pad PIN description of TP1282L1-FR.

Pin Configuration and Functions

TP1281L1
SOT23-5
Top View



TP1281L1
SOP8
Top View

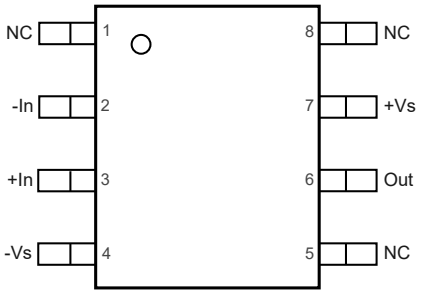
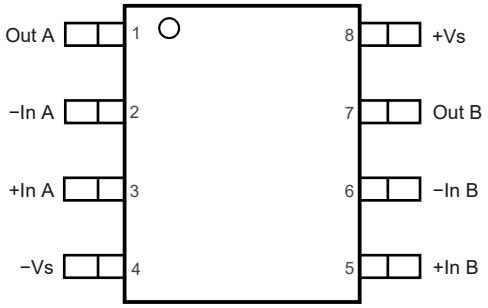


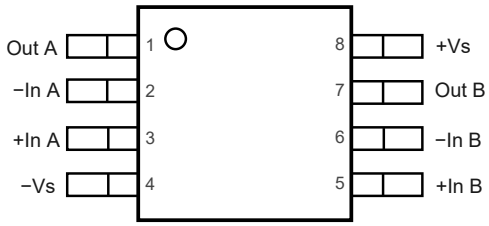
Table 1. Pin Functions: TP1281L1

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

TP1282L1
SOP8
Top View



TP1282L1
MSOP8
Top View



TP1282L1
DFN2X2-8
Top View

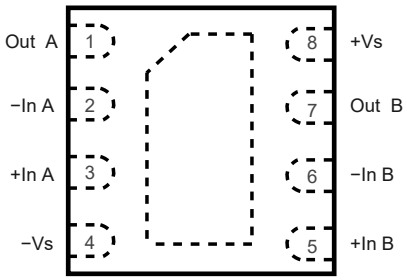
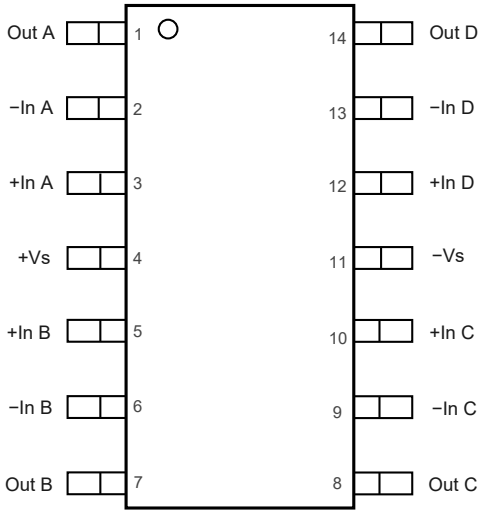


Table 2. Pin Functions: TP1282L1

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	$-V_S$		Negative power supply
5	+In B	I	Non-inverting input
6	−In B	I	Inverting input
7	Out B	O	Output
8	$+V_S$		Positive power supply
	Thermal Pad		The underneath exposed pad for thermal enhancement. Connect the thermal pad to $-V_S$ plane for better thermal performance of the device.

TP1284
SOP14
Top View



TP1284
TSSOP14
Top View

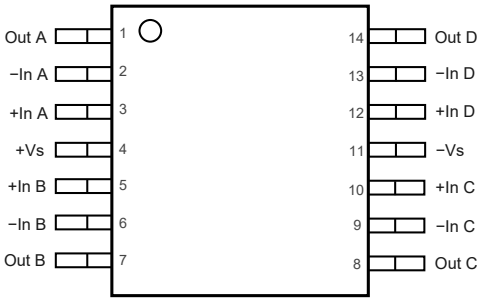


Table 3. Pin Functions: TP1284

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	$+V_S$		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	$-V_S$		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 (1)

Parameter		Min	Max	Unit
	Supply Voltage: $(+V_S) – (-V_S)$		40	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: +IN, –IN (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 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 (1)	4	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 (2)	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	θ_{JA}	θ_{JC}	Unit
SOT23-5	250	81	°C/W
SOP8	158	43	°C/W
MSOP8	210	45	°C/W
DFN2X2-8	100	60	°C/W
SOP14	120	36	°C/W
TSSOP14	180	35	°C/W

Electrical Characteristics

All test conditions: V_S = 30 V, T_A = 25°C, R_L = 10 kΩ, unless otherwise noted.

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

Symbol	Parameter	Conditions	T_A	Min	Typ	Max	Unit
C_{IN}	Input Capacitance	Differential mode			5		pF
		Common mode			2.5		pF
A_V	Open-Loop Voltage Gain	V_S = 30 V, V_{OUT} = 0.5 V to 29.5 V		120	130		dB
			−40°C to 125°C	105			dB
V_{CMR}	Common-Mode Input Voltage Range			($-V_S$)		($+V_S$) – 1.5	V
CMRR	Common-Mode Rejection Ratio	V_{CM} = 0.5 V to 28.5 V		100	125		dB
			−40°C to 125°C	95			dB
Output Characteristics							
V_{OH}	Output Swing from Positive Rail	R_{LOAD} = 100 kΩ to V_S / 2			5	15	mV
			−40°C to 85°C			30	mV
			−40°C to 125°C			40	mV
		R_{LOAD} = 10 kΩ to V_S / 2			50	80	mV
			−40°C to 85°C			120	mV
			−40°C to 125°C			130	mV
V_{OL}	Output Swing from Negative Rail	R_{LOAD} = 100 kΩ to V_S / 2			5	10	mV
			−40°C to 85°C			20	mV
			−40°C to 125°C			25	mV
		R_{LOAD} = 10 kΩ to V_S / 2			40	50	mV
			−40°C to 85°C			80	mV
			−40°C to 125°C			100	mV
I_{SC}	Output Short-Circuit Current	Source current		20	32		mA
		Sink current		15	25		mA
AC Specifications							
GBW	Gain-Bandwidth Product				7		MHz
SR	Slew Rate	G = 1, 10-V step		13	20		V/μs
			−40°C to 125°C	10			V/μs
t_{OR}	Overload Recovery				100		ns
t_S	Settling Time, 0.1%	G = −1, 10-V step			0.5		μs
	Settling Time, 0.01%				0.8		μs
PM	Phase Margin	V_S = 36 V, R_L = 10 kΩ, C_L = 100 pF			60		°
GM	Gain Margin	V_S = 36 V, R_L = 10 kΩ, C_L = 100 pF			10		dB

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

Typical Performance Characteristics

All test conditions: V_S = ±15 V, V_{CM} = 0 V, R_L = 10 kΩ, unless otherwise specified.

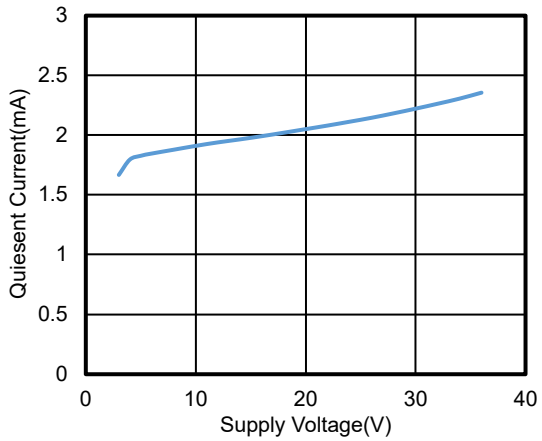


Figure 1. Quiescent Current vs. Supply Voltage, TP1282

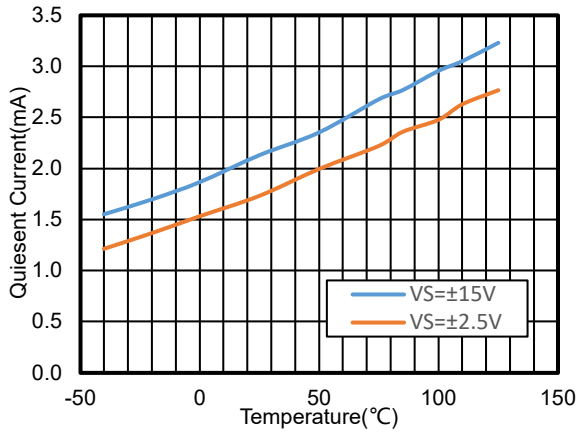


Figure 2. Quiescent Current vs. Temperature, TP1282

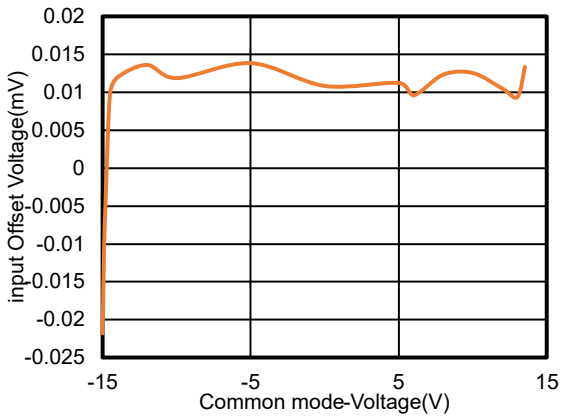


Figure 3. Offset Voltage vs. Common-Mode Voltage

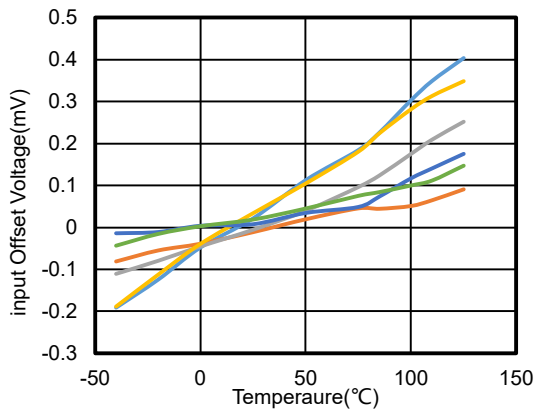


Figure 4. V_{OS} vs. Temperature

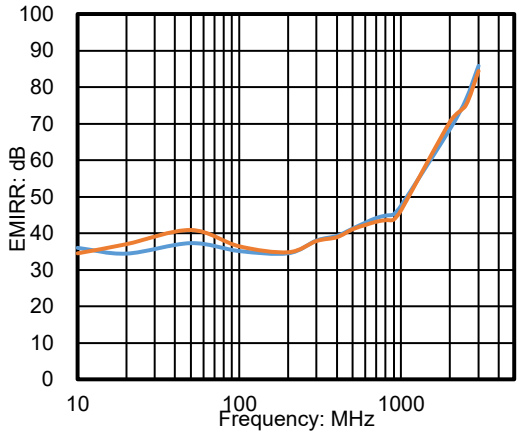


Figure 5. EMIRR vs. Frequency

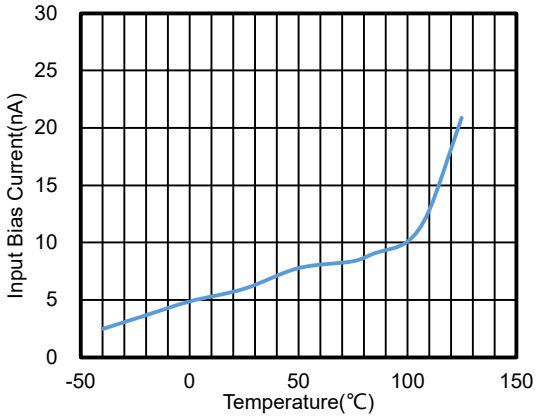


Figure 6. Input Current in Large V_{DM} vs. Temperature

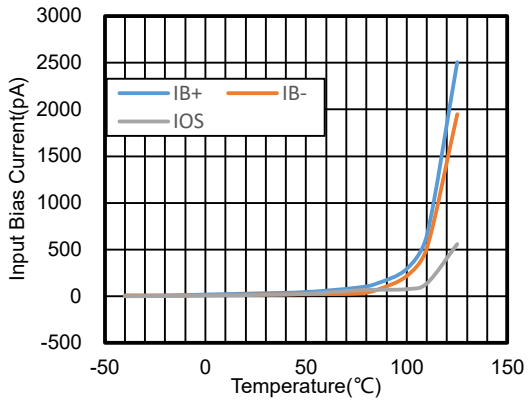


Figure 7. I_B vs. Temperature, −40 to 125°C

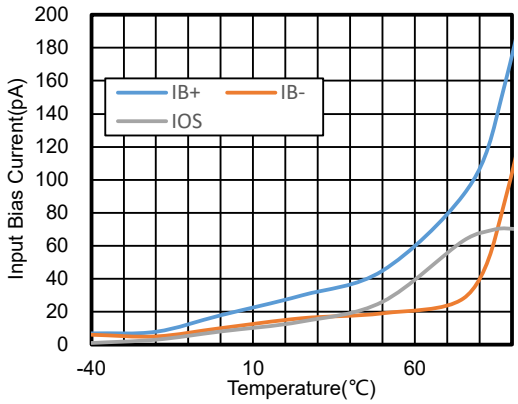


Figure 8. I_B vs. Temperature, −40 to 90°C

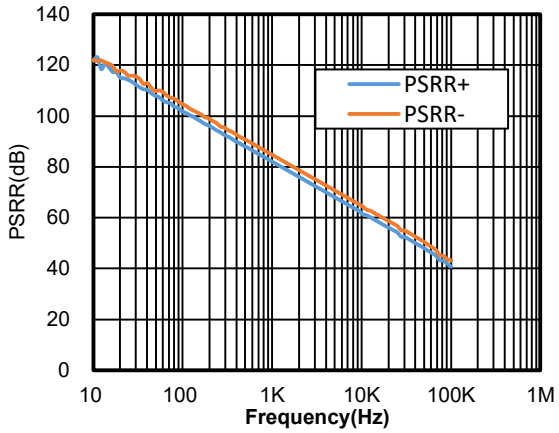


Figure 9. PSRR vs. Frequency

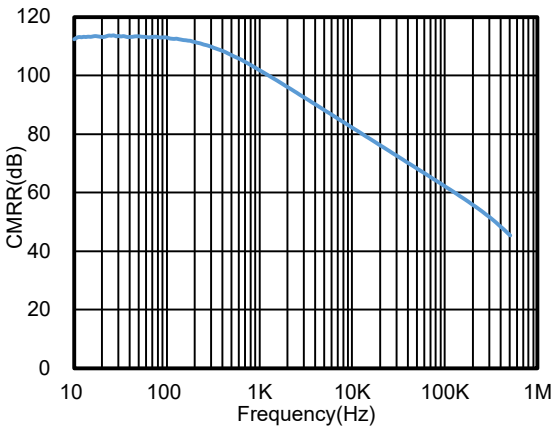


Figure 10. CMRR vs. Frequency

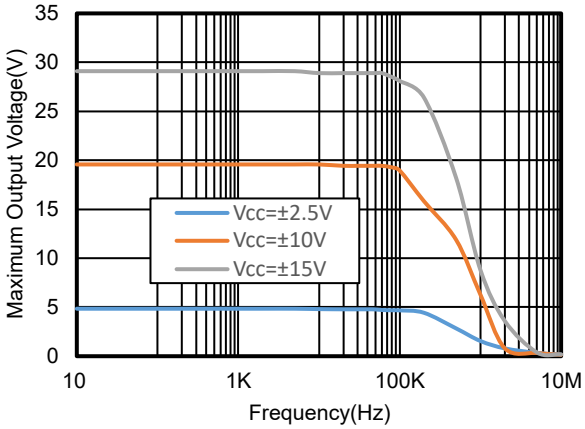
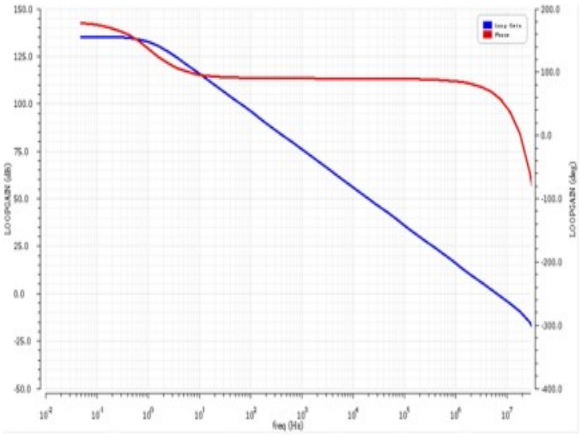


Figure 11. Maximum Output Voltage vs. Frequency



R_{LOAD} = 10 K, C_{LOAD} = 100 pF

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

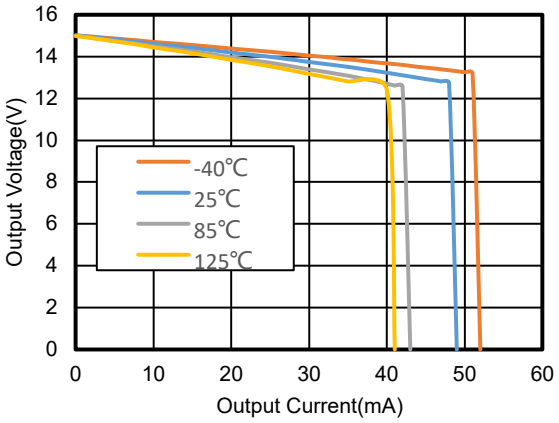


Figure 13. Positive Output Voltage vs. Output Current

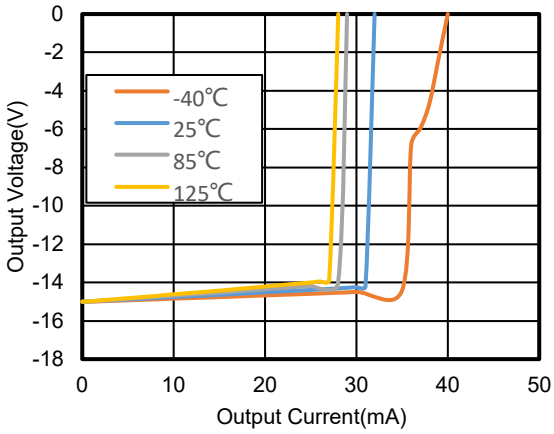


Figure 14. Negative Output Voltage vs. Output Current

Figure 15. Positive Overload Recovery

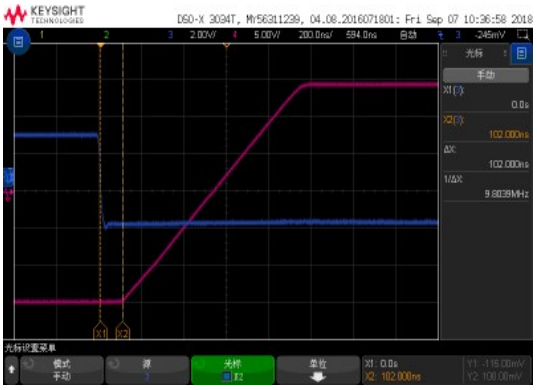
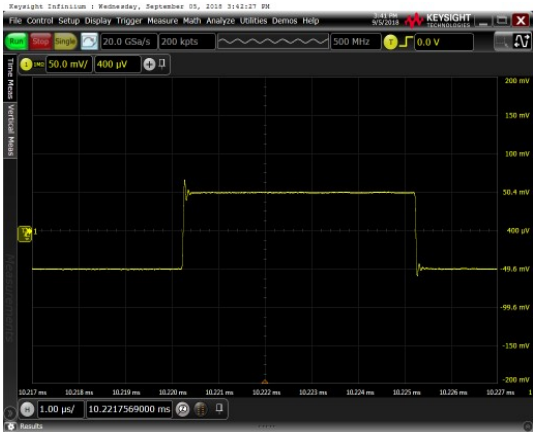


Figure 16. Negative Overload Recovery



Voltage: 50 mV/div, Time: 1 μs/div

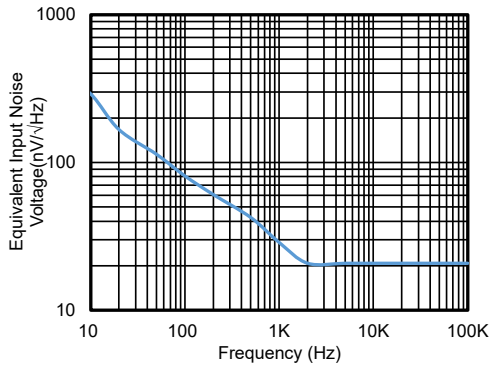
R_L = 2 kΩ, C_L = 100 pF, G = 1

Figure 17. 100-mV Signal Step Response

Voltage: 5 V/div, Time: 1 μs/div

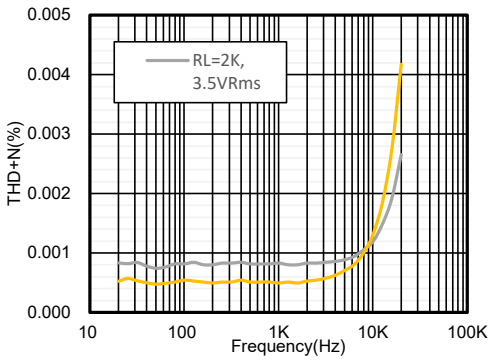
R_L = 2 kΩ, C_L = 100 pF, G = 1

Figure 18. 10-V Signal Step Response



V_S = ± 15 V, V_{CM} = 0 V

Figure 19. Voltage Noise Spectral Density vs. Frequency



V_S = ± 15 V, V_{CM} = 0 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

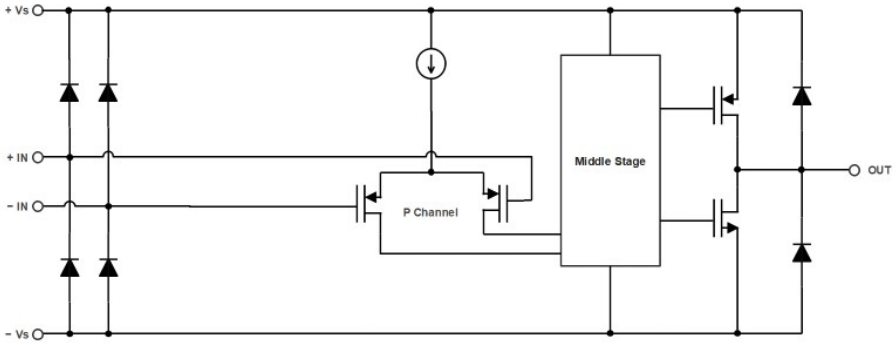


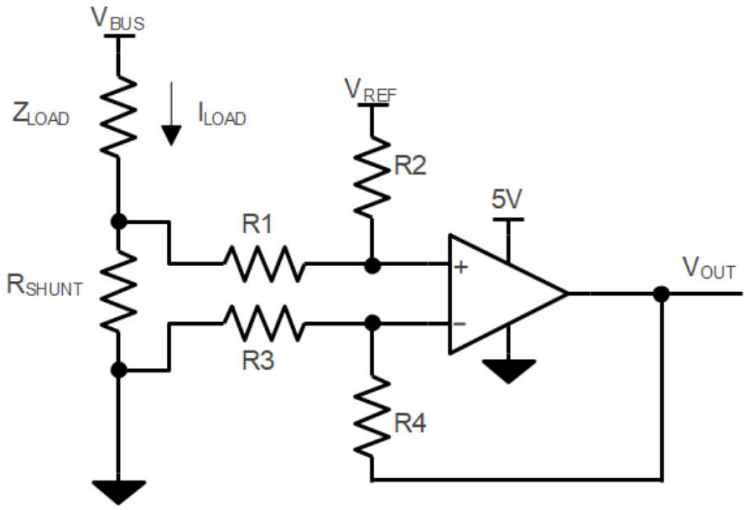
Figure 21. Functional Block Diagram

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.

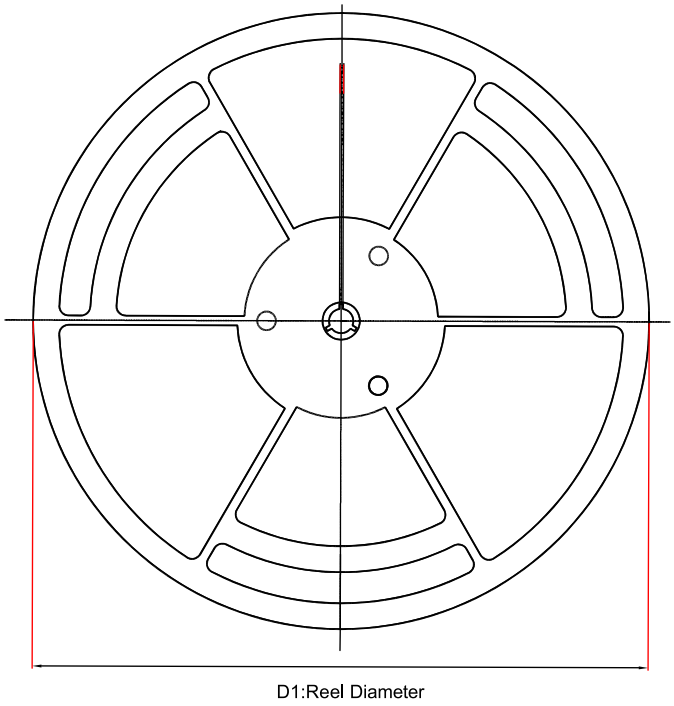


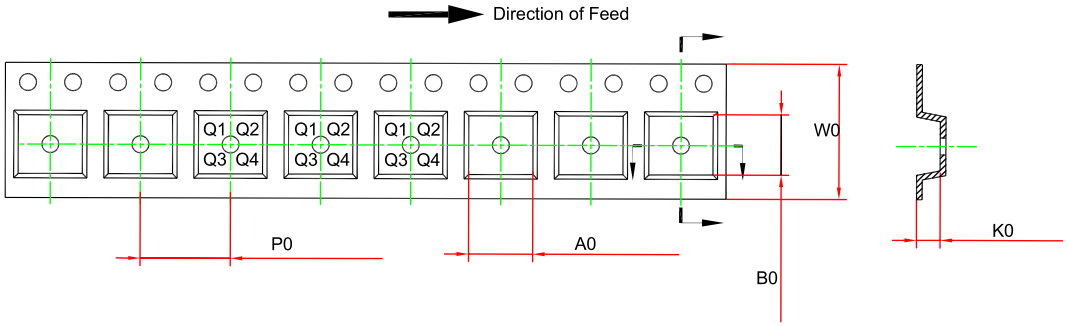
$$V_{OUT} = (I_{LOAD} \times R_{SHUNT}) \times (R2 / R1) + V_{REF}$$

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

Figure 22. Typical Application Circuit

Tape and Reel Information





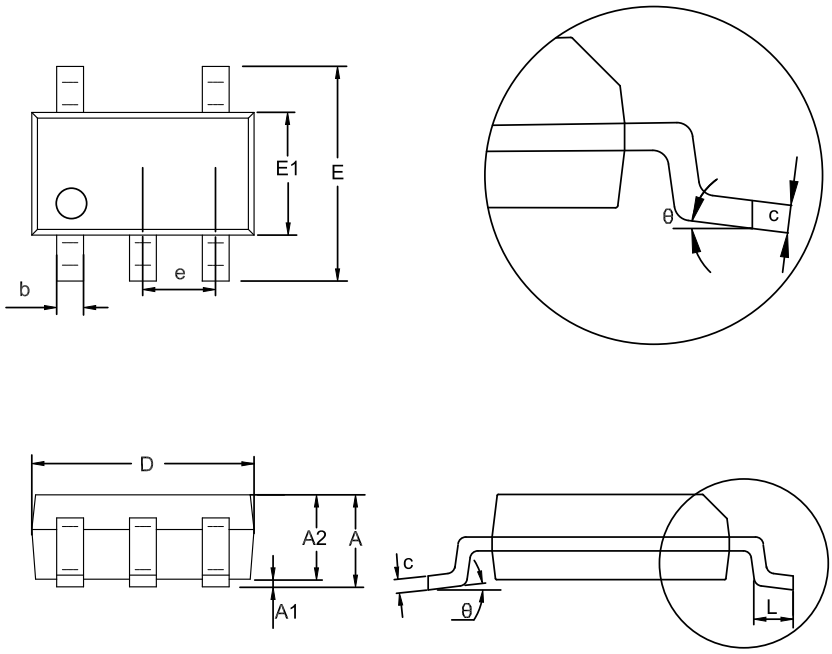
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) (1)	B0 (mm) (1)	K0 (mm) (1)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TP1281L1-TR	SOT23-5	180.0	12.0	3.3	3.25	1.4	4.0	8.0	Q3
TP1282L1-SR	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TP1282L1-VR	MSOP8	330.0	17.6	5.2	3.3	1.5	8.0	12.0	Q1
TP1282L1-FR	DFN2X2-8	180.0	13.1	2.3	2.3	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

Package Outline Dimensions S5T(SOT23-5-A)



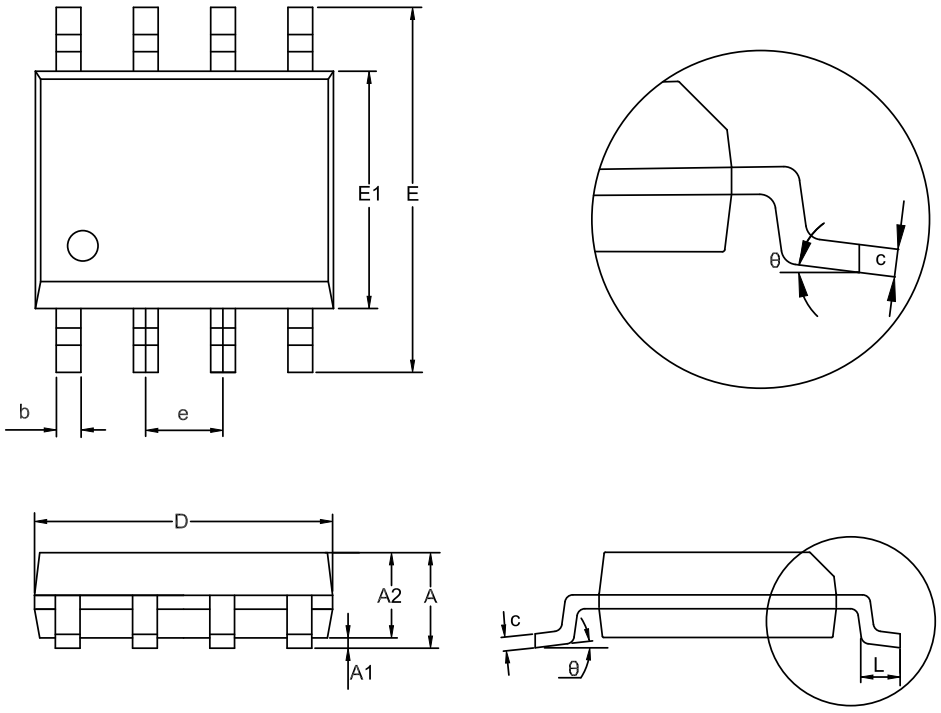
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.280	0.500	0.011	0.020
c	0.100	0.230	0.004	0.009
D	2.820	3.020	0.111	0.119
E	2.600	3.000	0.102	0.118
E1	1.500	1.720	0.059	0.068
e	0.950 BSC		0.037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



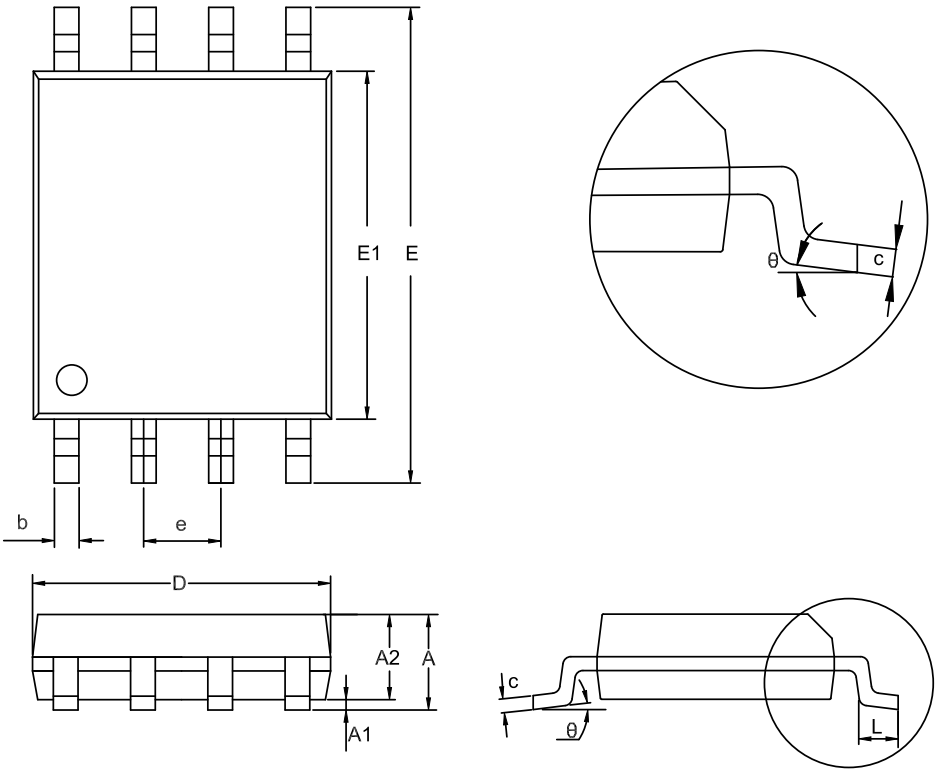
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050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

TSSOP8

Package Outline Dimensions TS1(TSSOP-8-A)



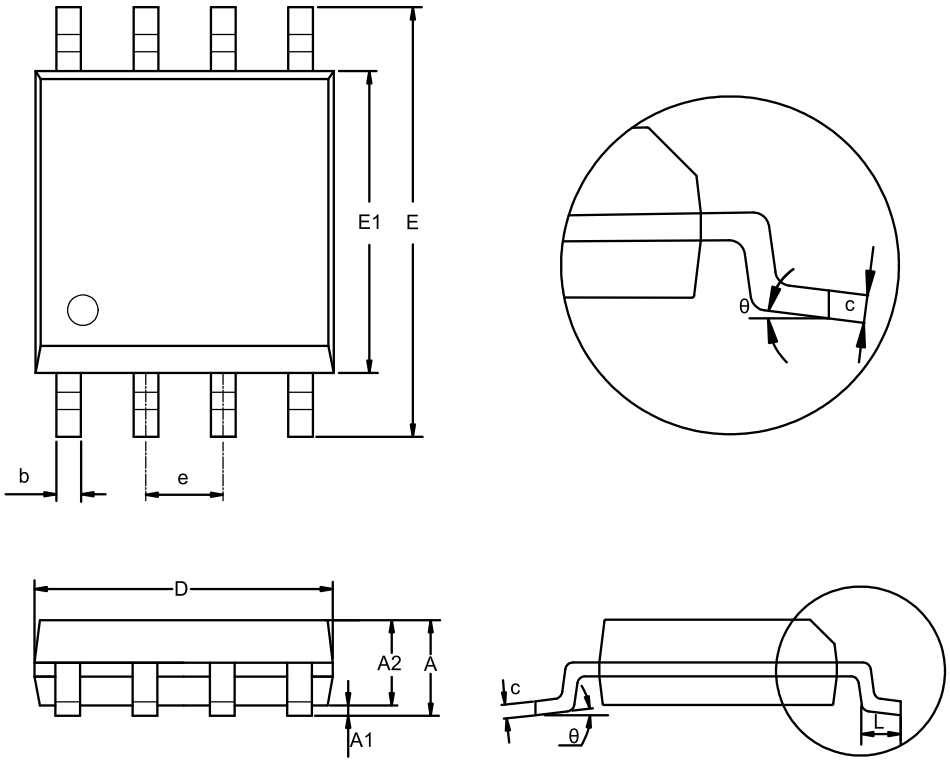
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.200	0.035	0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	2.900	3.100	0.114	0.122
E	6.200	6.600	0.244	0.260
E1	4.300	4.500	0.169	0.177
e	0.650 BSC		0.026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

MSOP8

Package Outline Dimensions VS1(MSOP-8-A)



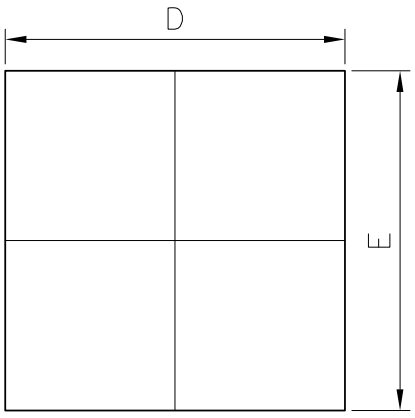
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.650 BSC		0.026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

NOTES

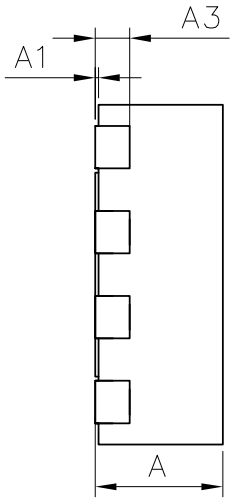
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

DFN2X2-8

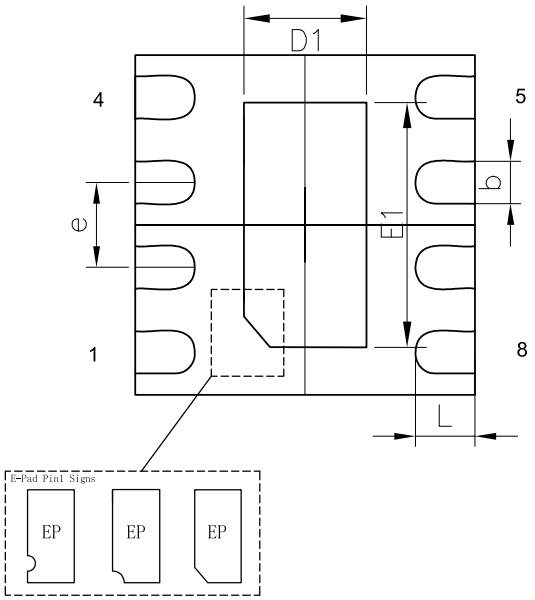
Package Outline Dimensions DFJ(DFN2X2-8-G)



Top View



Side View



Bottom View

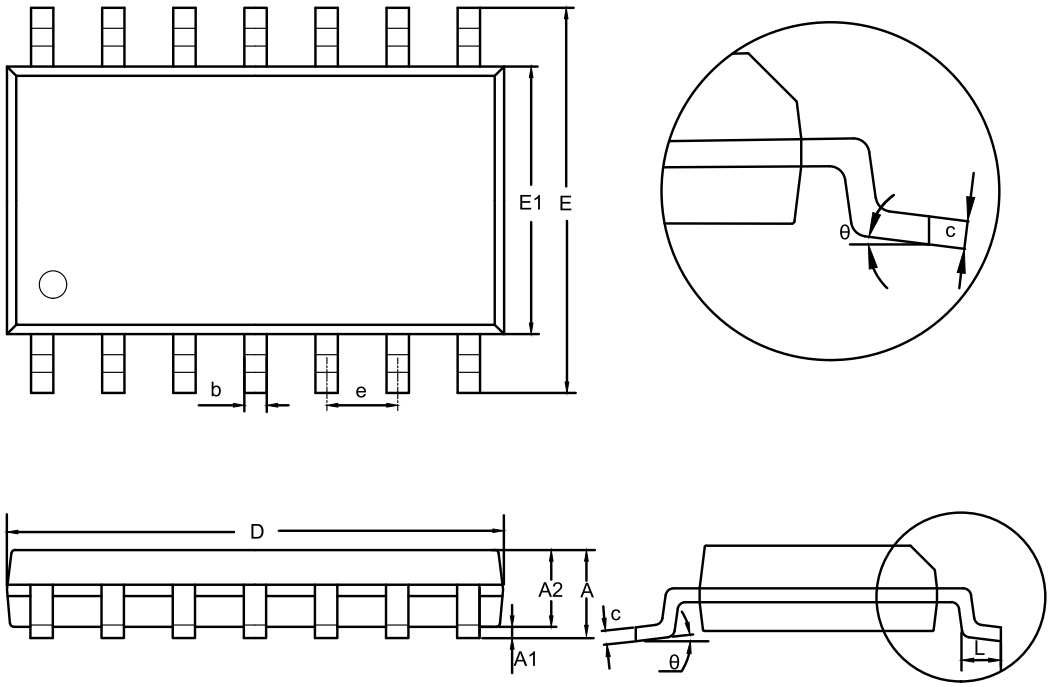
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	0.900	0.031	0.035
A1	0.000	0.050	0.000	0.002
b	0.180	0.300	0.007	0.012
A3	0.150	0.250	0.006	0.010
D	1.900	2.100	0.075	0.083
D1	0.750	0.850	0.030	0.033
E	1.900	2.100	0.075	0.083
E1	1.550	1.650	0.061	0.065
e	0.500 BSC		0.020BSC	
L	0.250	0.350	0.010	0.014

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.
3. The many types of E-pad Pin1 signs may appear in the product.

SOP14

Package Outline Dimensions SO2(SOP-14-A)



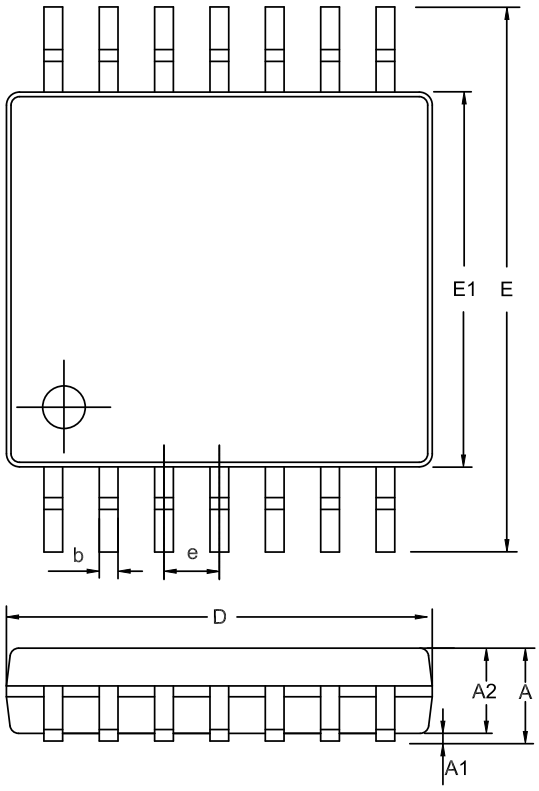
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.650	0.049	0.065
b	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D	8.450	8.850	0.333	0.348
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0	8°	0	8°

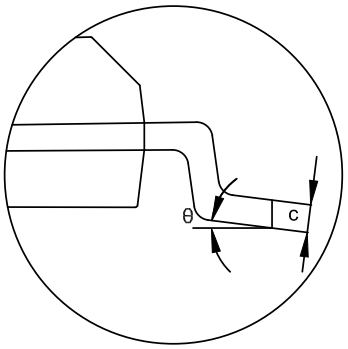
NOTES

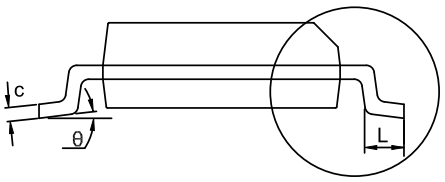
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

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
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 (1)	−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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