36-V, 3.5-MHz, 15-V/μs Operational Amplifier

Features

- Supply Voltage: 3 V to 36 V
- Low Supply Current: 1000 μA per Channel (Max)
- Differential Input Voltage Range to Supply Rail, can Work as Comparator
- Input Rail to $-V_S$, Rail-to-Rail Output
- Fast Response: 3.5-MHz Bandwidth, 15-V/μs Slew Rate, 100-ns Overload Recovery
- Low Offset Voltage:
  - ±2 mV at 25°C (Max)
  - ±2.5 mV at −40°C to 85°C (Max)
  - ±3 mV at −40°C to 125°C (Max)
- Very Low THD+N: 0.0005% at Gain = 1, 1 kHz
- Excellent EMIRR: 60 dB at 900 MHz
- 2-kV HBM, 1-kV CDM, 150-mA Latch Up
- Operating Temperature Range: −40°C to 125°C

Applications

- Sensor Interface
- Motor Control
- Industrial Control
- Audio

Description

The TP226x is a series of the newest high supply voltage amplifiers with low offset, low power, and stable high-frequency response. The TP226x series incorporates 3PEAK's proprietary and patented design techniques to achieve excellent AC performance with a 3.5-MHz bandwidth, a 15-V/μs slew rate, and low distortion while drawing a quiescent current of only typical 700 μA per amplifier. The input common-mode voltage range extends to $–V_S$, and the outputs swing rail-to-rail. The TP226x series can be used as plug-in replacements for commercially available op amps to reduce power consumption, extend input/output range, and improve performance.

The combination of features makes the TP226x series an ideal choice for industrial control, motor control and portable audio amplification, sound ports, and other consumer audio.

Table of Contents

Revision History

Date	Revision	Notes
2017-12-21	Rev.Pre.0	Pre-released version.
2018-09-09	Rev.0.0	Initial version.
2018-12-21	Rev.0.1	Added new part numbers: TP2262L1-TSR, TP2261L1-TR. Updated the marking information: Added "TP" before "226" on SOP8 and SOP14 packages.
2019-02-15	Rev.0.2	Added a new part number: TP2262-F2R. Updated Package Outline Dimensions.
2019-03-30	Rev.0.3	Updated the date code information. Updated Package Outline Dimensions.
2019-05-30	Rev.0.4	Added Figure 29: Crosstalk vs. Frequency.
2020-09-24	Rev.A.0	Updated the description of Absolute Maximum Ratings: from "Maximum Junction Temperature" to "Maximum Operating Junction Temperature". Added the part number: TP2262-FR; Removed the part number: TP2261L1-TR.
2021-04-10	Rev.A.1	Removed the part numbers: TP2262L1-SR, TP2262L1-TSR, TP2264L1-TSR.
2024-12-17	Rev.A.2	Updated to a new datasheet format. Updated the POD, Tape and Reel table. Updated the Order Information.

Pin Configuration and Functions

TP2261
SOT23-5
Top View

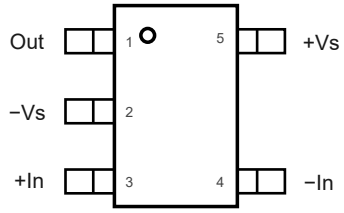


Table 1. Pin Functions: TP2261

Pin No.	Name	I/O	Description
1	Out	O	Output
2	$-V_S$		Negative power supply
3	+In	I	Non-inverting input
4	−In	I	Inverting input
5	$+V_S$		Positive power supply

TP2261
SOP8
Top View

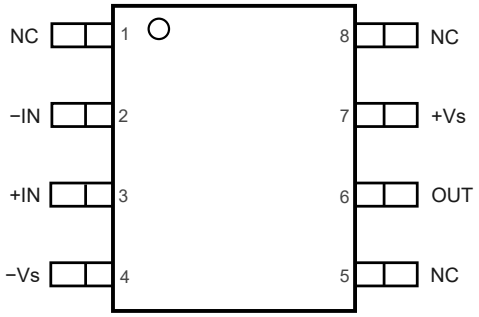
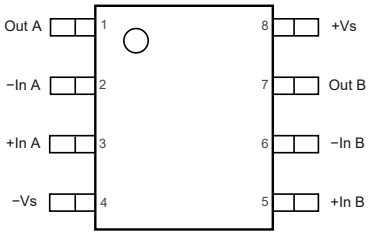


Table 2. Pin Functions: TP2261

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

TP2262
SOP8/TSSOP8/MSOP8
Top View



TP2264
SOP14/TSSOP14
Top View

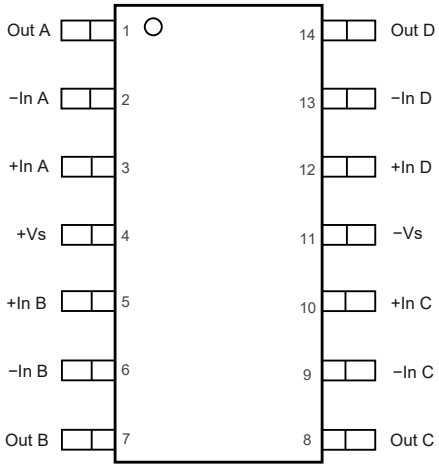
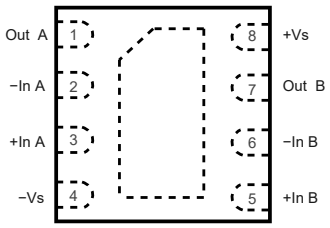


Table 3. Pin Functions: TP2262, TP2264

Pin No.		Name	I/O	Description
TP2262	TP2264			
1	1	Out A	O	Output
2	2	−In A	I	Inverting input
3	3	+In A	I	Non-inverting input
4	11	$-V_S$		Negative power supply
5	5	+In B	I	Non-inverting input
6	6	−In B	I	Inverting input
7	7	Out B	O	Output
8	4	$+V_S$		Positive power supply
	8	Out C	O	Output
	9	−In C	I	Inverting input
	10	+In C	I	Non-inverting input
	12	+In D	I	Non-inverting input
	13	−In D	I	Inverting input
	14	Out D	O	Output

TP2262
DFN2×2-8/DFN3×3-8
Top View



The thermal pad of the DFN package is recommended to be left float or connected to $-V_S$.

Table 4. Pin Functions: TP2262

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

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
	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 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. The 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)	2	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 (2)	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
TSSOP8	191	44	°C/W
DFN3×3-8	120	50	°C/W
MSOP8	210	45	°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 to V_S / 2, unless otherwise noted.

Symbol	Parameter	Conditions	T_A	Min	Typ	Max	Unit
Power Supply							
V_S	Supply Voltage Range			3		36	V
I_Q	Quiescent Current per Amplifier	V_S = 30 V, TP2261			1000	1500	μA
			−40°C to 125°C			1700	μA
		V_S = 5 V, TP2261			850	1300	μA
			−40°C to 125°C			1500	μA
		V_S = 30 V, TP2262/2264			700	1000	μA
			−40°C to 125°C			1200	uA
		V_S = 5 V, TP2262/2264			600	850	μA
			−40°C to 125°C			1000	μA
PSRR	Power Supply Rejection Ratio	V_S = 3 V to 36 V		95	120		dB
			−40°C to 125°C	90			dB
Input Characteristics							
V_{OS}	Input Offset Voltage	V_S = 30 V, V_{CM} = 0 V to 28 V		−2	0.1	2	mV
			−40°C to 85°C	−2.5		2.5	mV
			−40°C to 125°C	−3		3	mV
		V_S = 30 V, V_{CM} = 28.5 V		−3		3	mV
			−40°C to 125°C	−4		4	mV
		V_S = 5 V, V_{CM} = 2.5 V		−2	0.1	2	mV
			−40°C to 125°C	−3		3	mV
V_{OS} TC	Input Offset Voltage Drift		−40°C to 125°C		2		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}	Differential Input Current	V_S = 36 V, V_{ID} = 36 V			10		nA
			−40°C to 125°C		100		nA
C_{IN}	Input Capacitance	Differential mode			5		pF
		Common mode			2.5		pF
A_V	Open-Loop Voltage Gain			105	120		dB
			−40°C to 125°C	100			dB
V_{CMR}	Common-Mode Input Voltage Range			($-V_S$)		($+V_S$) − 1.5	V
CMRR	Common-Mode Rejection Ratio	V_{CM} = 0 V to 28 V		105	130		dB

Symbol	Parameter	Conditions	T_A	Min	Typ	Max	Unit
			−40°C to 125°C	100			dB
Output Characteristics							
V_{OH}	Output Swing from Positive Rail	R_{LOAD} = 10 kΩ to V_S / 2			200	300	mV
			−40°C to 125°C			450	mV
		R_{LOAD} = 2 kΩ to V_S / 2			1.1	1.4	V
			−40°C to 125°C			2	V
V_{OL}	Output Swing from Negative Rail	R_{LOAD} = 10 kΩ to V_S / 2			200	300	mV
			−40°C to 125°C			450	mV
		R_{LOAD} = 2 kΩ to V_S / 2			0.8	1	V
			−40°C to 125°C			1.6	V
I_{SC}	Output Short-Circuit Current			25	32		mA
			−40°C to 85°C	20			mA
			−40°C to 125°C	15			mA
AC Specifications							
GBW	Gain-Bandwidth Product				3.5		MHz
SR	Slew Rate	G = 1, 10-V step			15		V/μs
		Open loop		9	15		V/μs
			−40°C to 85°C	7			V/μs
			−40°C to 125°C	6			V/μs
t_{OR}	Overload Recovery				100		ns
t_S	Settling Time, 0.1%	G = −1, 10-V step			0.8		μs
	Settling Time, 0.01%				1		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			15		dB
Noise Performance							
E_N	Input Voltage Noise	f = 0.1 Hz to 10 Hz			1.7		μV_{RMS}
e_N	Input Voltage Noise Density	f = 1 kHz			30		nV/√Hz
i_N	Input Current Noise	f = 1 kHz			2		fA/√Hz
THD+N	Total Harmonic Distortion and Noise	f = 1 kHz, G = 1, R_L = 10 kΩ, V_{OUT} = 6 V_{RMS}			0.0005		%

Typical Performance Characteristics

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

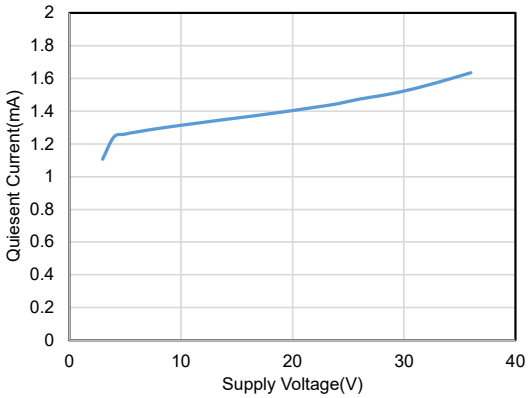


Figure 1. Quiescent Current vs. Supply Voltage, 2-Channel, TP2262

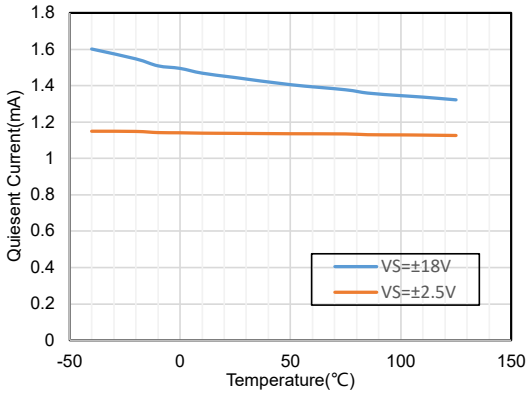


Figure 2. Quiescent Current vs. Temperature, 2-Channel, TP2262

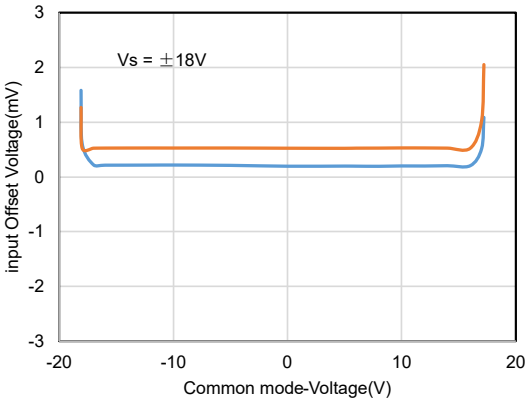


Figure 3. Offset Voltage vs. Common-Mode Voltage

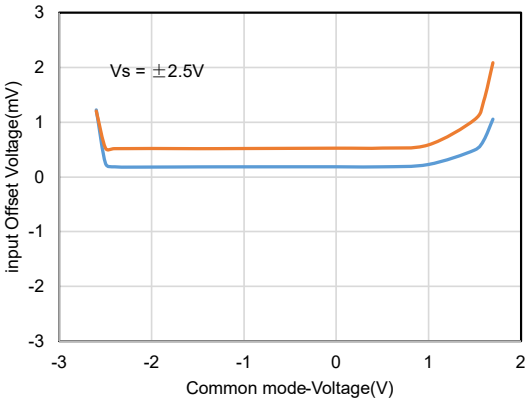


Figure 4. Offset Voltage vs. Common-Mode Voltage

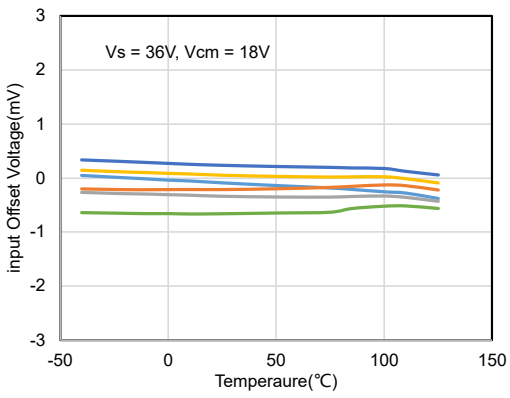


Figure 5. V_{OS} vs. Temperature

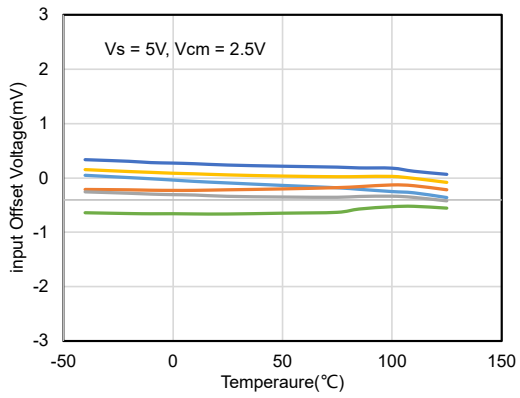


Figure 6. V_{OS} vs. Temperature

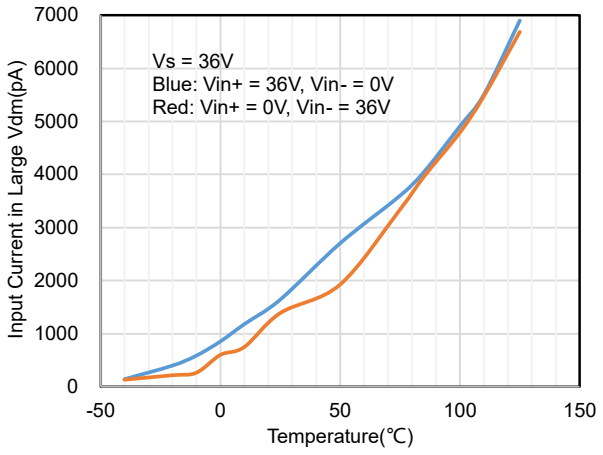


Figure 7. Input Current in Large V_{DM} vs. Temperature

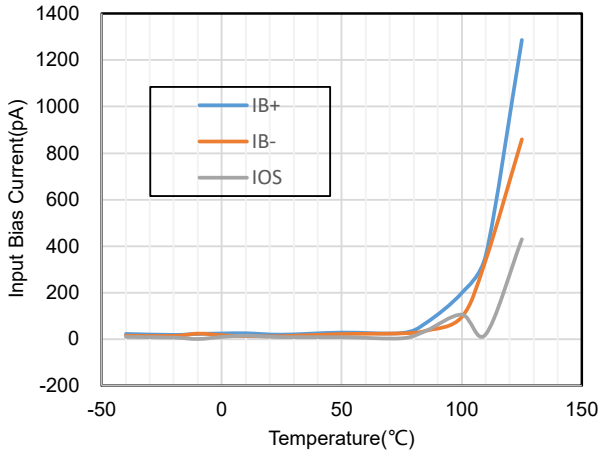


Figure 8. I_B vs. Temperature

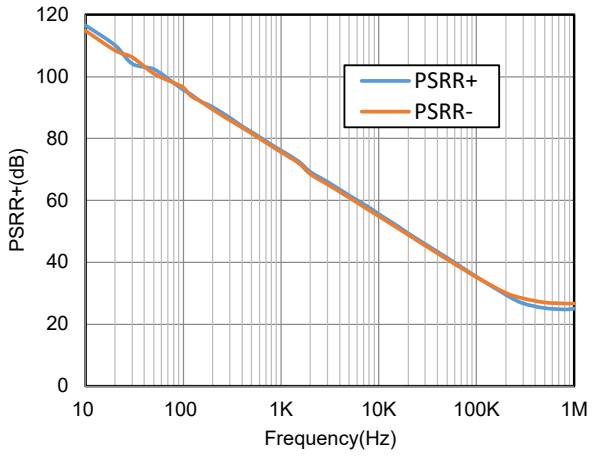


Figure 9. PSRR vs. Frequency

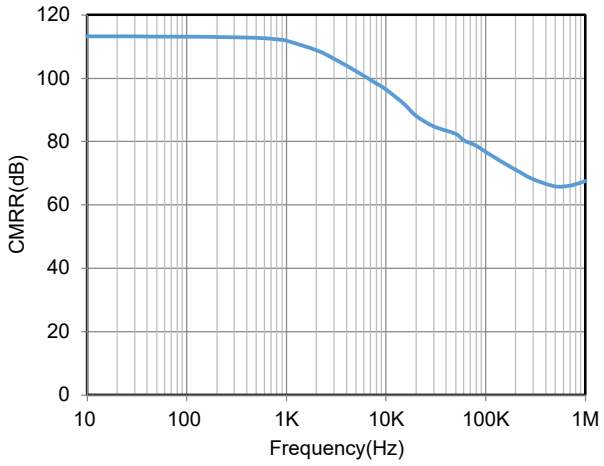


Figure 10. CMRR vs. Frequency

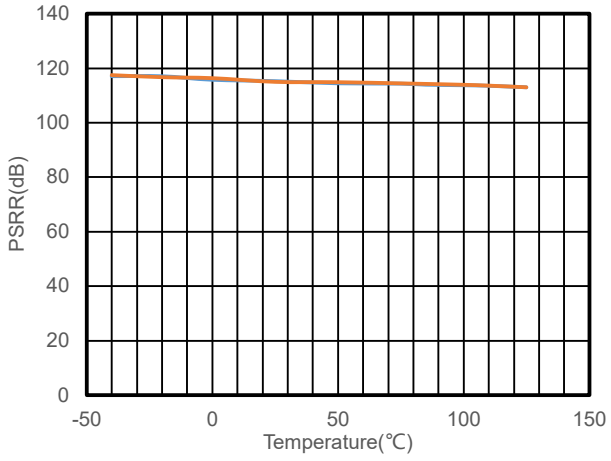


Figure 11. PSRR vs. Temperature

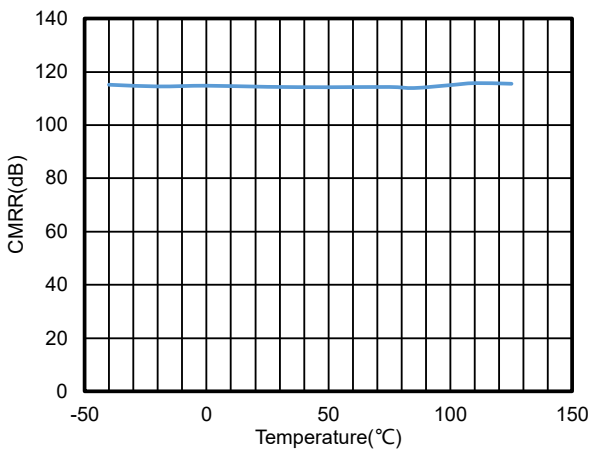


Figure 12. CMRR vs. Temperature

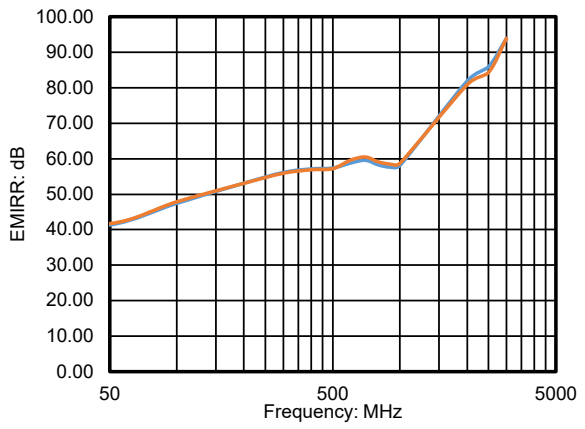


Figure 13. EMIRR IN+ vs. Frequency

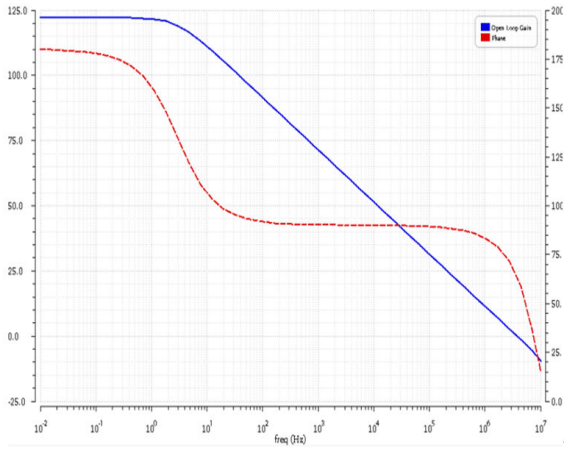


Figure 14. Open-Loop Gain and Phase vs. Frequency

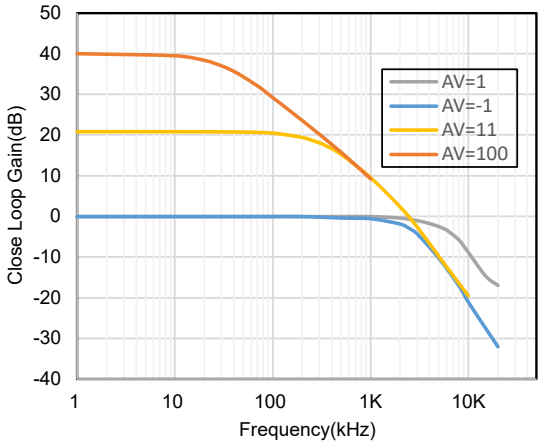
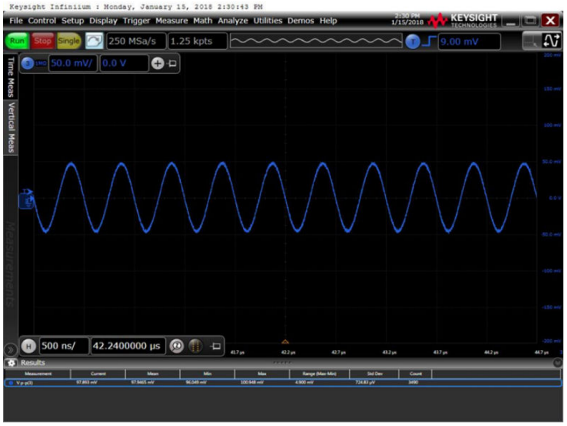


Figure 15. Close-Loop Gain and Phase vs. Frequency



V_S = ±1.5 V, V_{IN} = 100 mV_{PP}, R_L = 10 kΩ, C_L = 100 pF, G = 1

Figure 16. Waveform under 3-V Supply Voltage

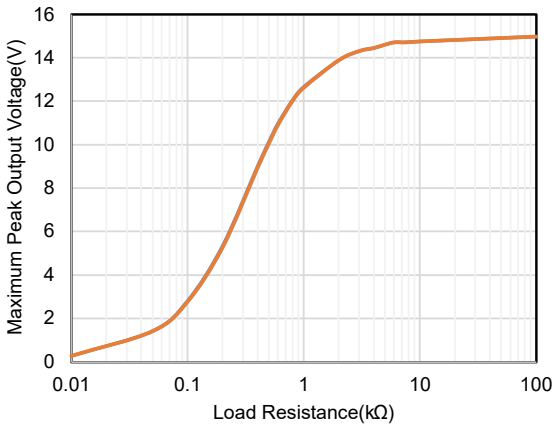


Figure 17. Maximum Peak Output Voltage vs. Load Resistance

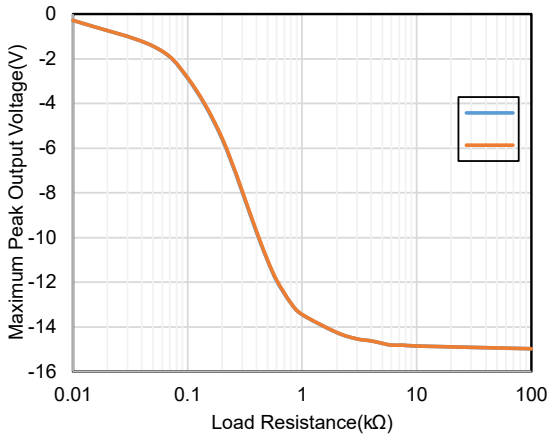


Figure 18. Maximum Peak Output Voltage vs. Load Resistance

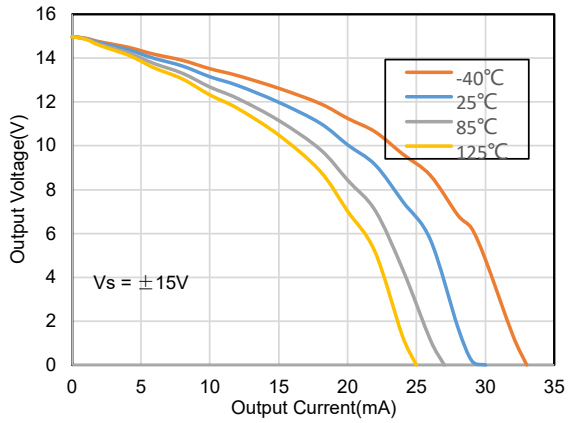


Figure 19. Positive Output Voltage vs. Output Current

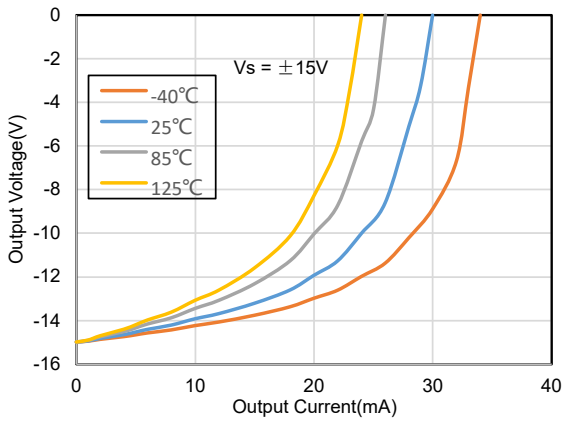


Figure 20. Negative Output Voltage vs. Output Current

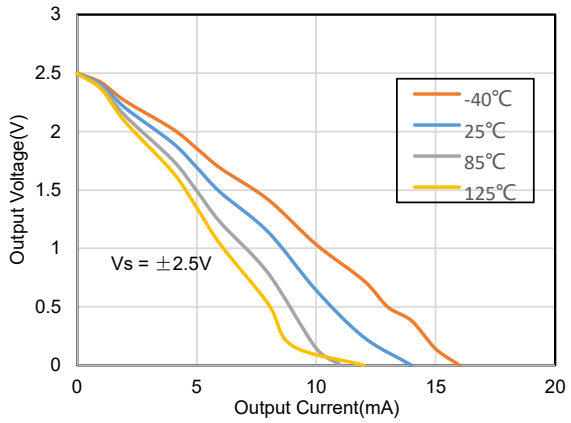


Figure 21. Positive Output Voltage vs. Output Current

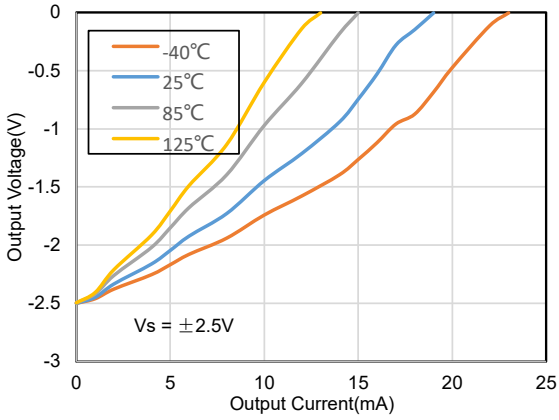


Figure 22. Negative Output Voltage vs. Output Current

Voltage: 1 V/div, Time: 200 ns/div

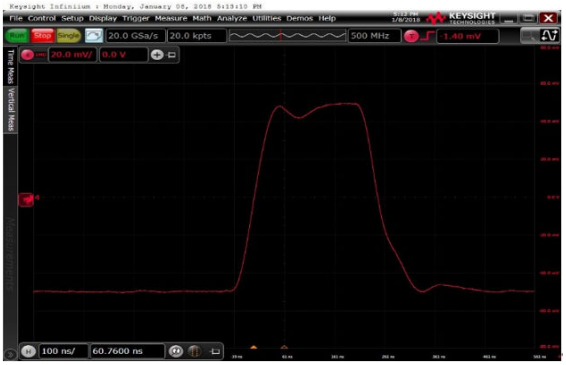
V_S = 5 V, V_{IN} = 2 V, R_L = Open, G = 3

Figure 23. Positive Overload Recovery

Voltage: 1 V/div, Time: 200 ns/div

V_S = 5 V, V_{IN} = 2 V, R_L = Open, G = 3

Figure 24. Negative Overload Recovery



Voltage: 20 mV/div, Time: 100 ns/div

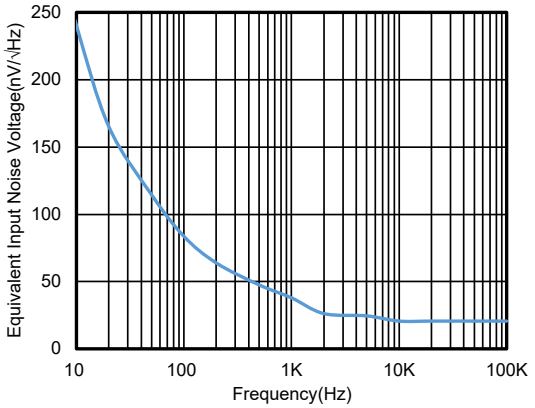
V_S = ±15 V, R_L = 2 kΩ, C_L = 100 pF, G = 1

Figure 25. 100-mV Signal Step Response

Voltage: 2 V/div, Time: 1 μs/div

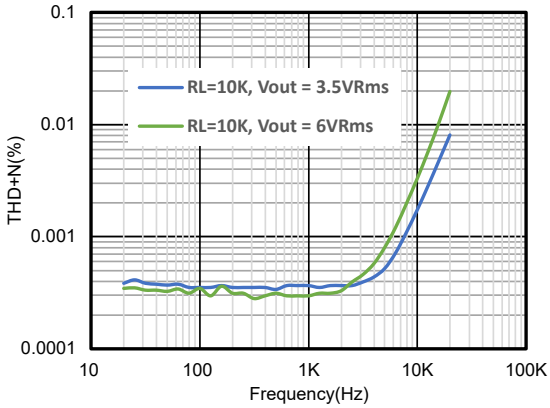
V_S = ±15 V, R_L = 2 kΩ, C_L = 100 pF, G = 1

Figure 26. 10-V Signal Step Response



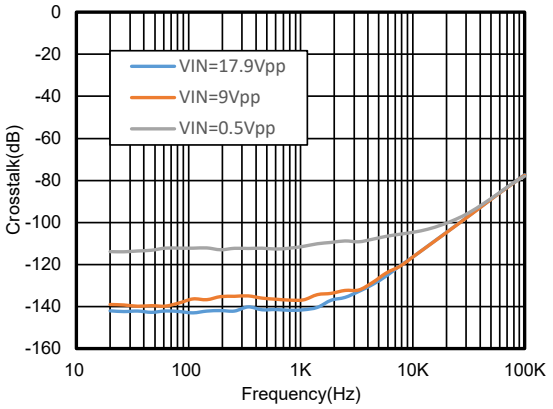
V_S = ±15 V, V_{CM} = 0 V

Figure 27. Voltage Noise Spectral Density vs. Frequency



V_S = ±15 V, V_{CM} = 0 V, G = 1

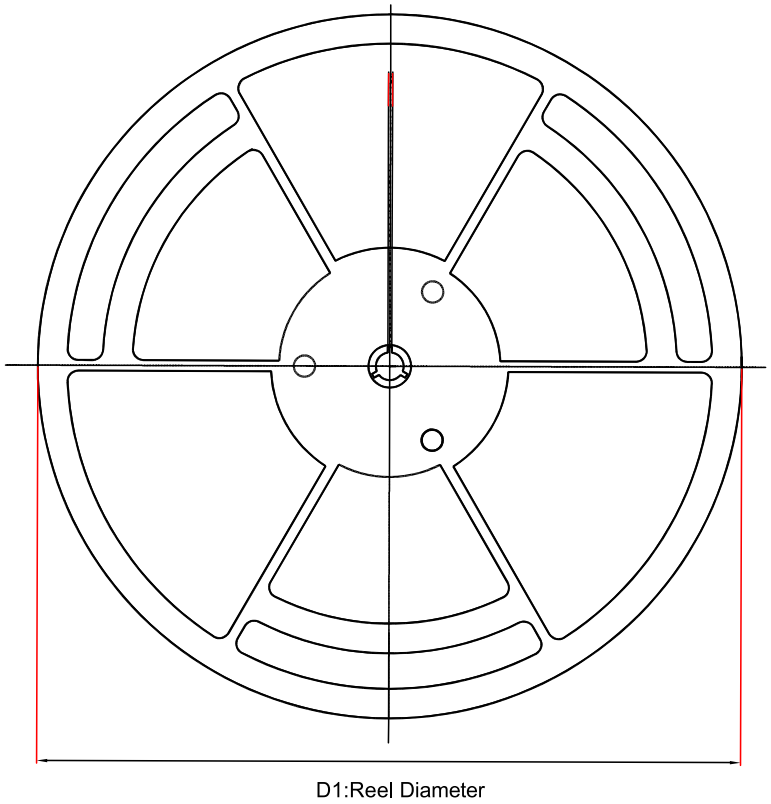
Figure 28. THD+N vs. Frequency

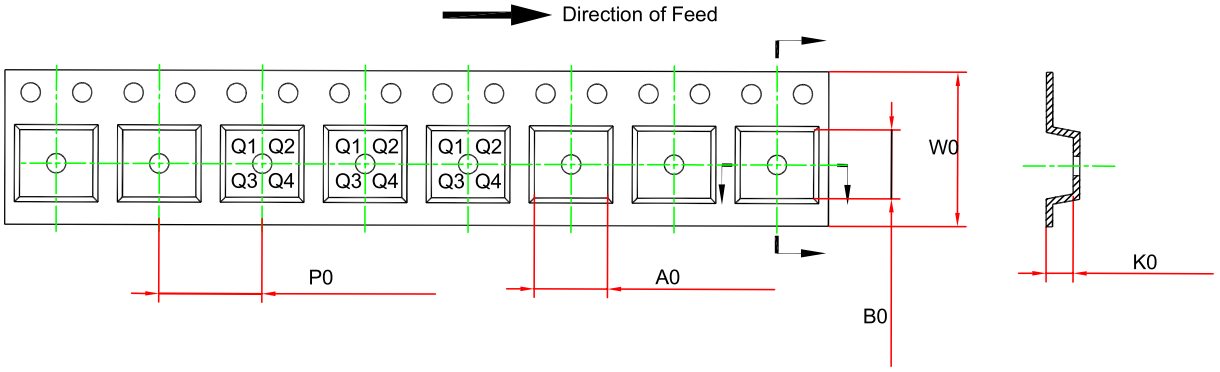


V_S = ±15 V, V_{CM} = 0 V

Figure 29. Crosstalk vs. Frequency

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
TP2261-SR	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
TP2261-TR	SOT23-5	180	12	3.3	3.25	1.4	4	8	Q3
TP2262-SR	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
TP2262-TSR	TSSOP8	330	17.6	6.8	3.4	1.8	8	12	Q1
TP2262-VR	MSOP8	330	17.6	5.3	3.4	1.3	8	12	Q1
TP2264-SR	SOP14	330	21.6	6.5	9.3	2.1	8	16	Q1

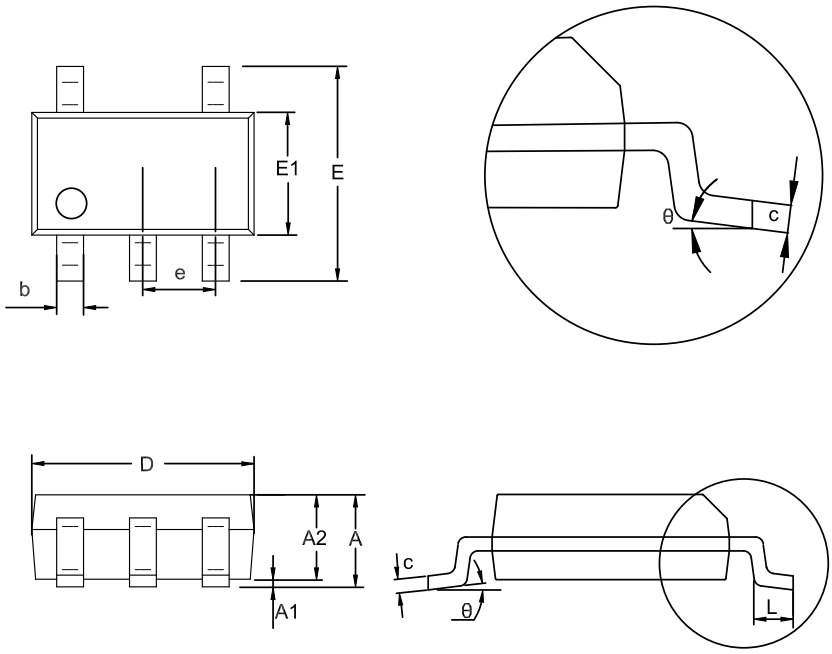
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) (1)	B0 (mm) (1)	K0 (mm) (1)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TP2264-TR	TSSOP14	330	17.6	6.8	5.5	1.5	8	12	Q1

(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)



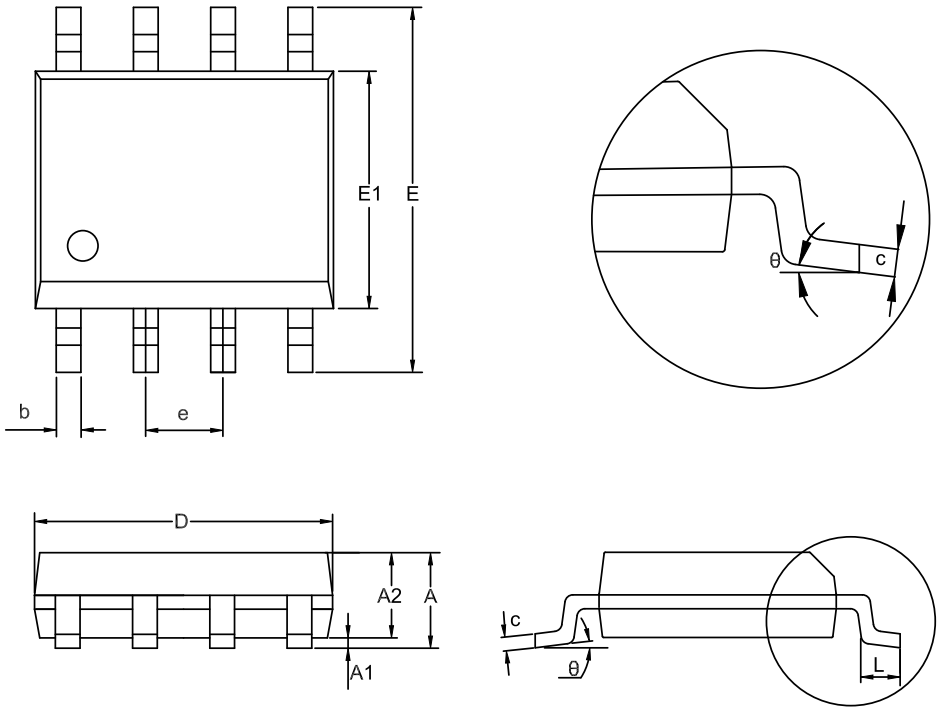
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.280	0.500	0.011	0.020
c	0.100	0.230	0.004	0.009
D	2.820	3.020	0.111	0.119
E	2.600	3.000	0.102	0.118
E1	1.500	1.720	0.059	0.068
e	0.950 BSC		0.037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



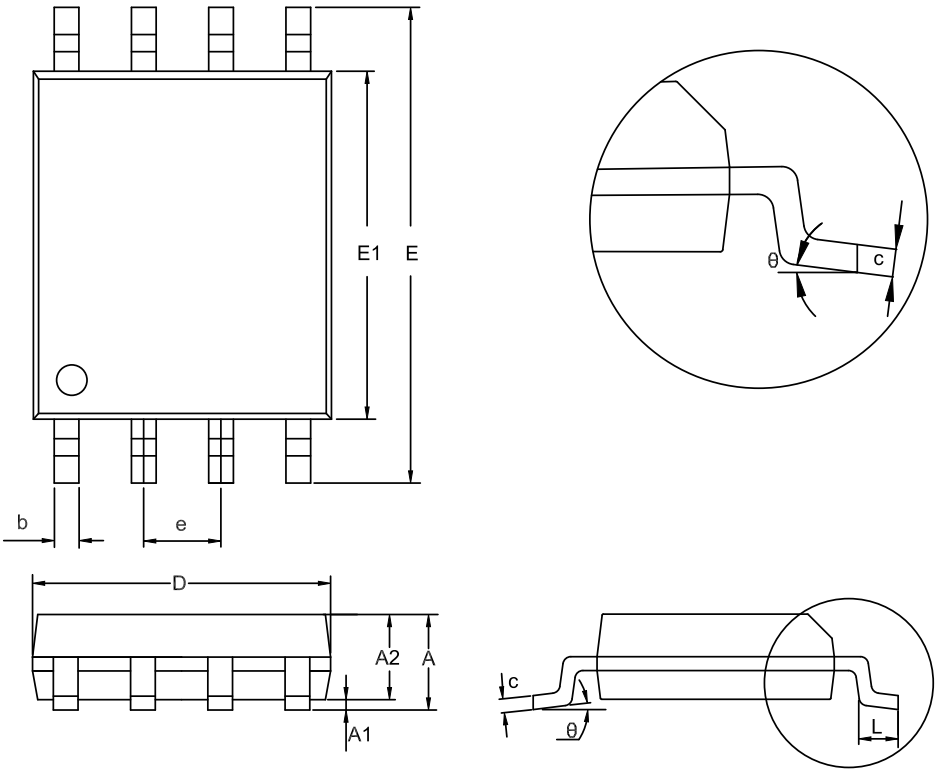
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050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



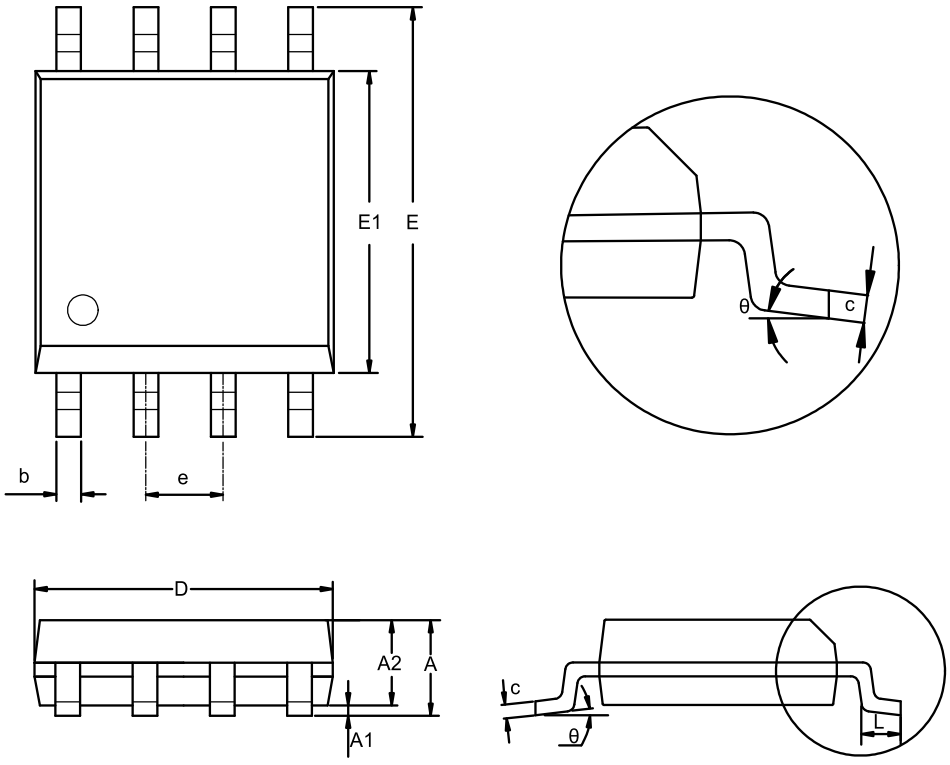
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.200	0.035	0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	2.900	3.100	0.114	0.122
E	6.200	6.600	0.244	0.260
E1	4.300	4.500	0.169	0.177
e	0.650 BSC		0.026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



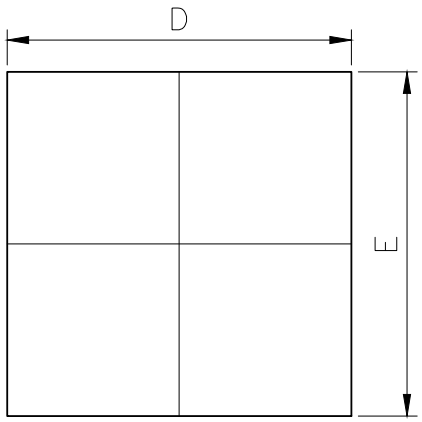
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.650 BSC		0.026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

NOTES

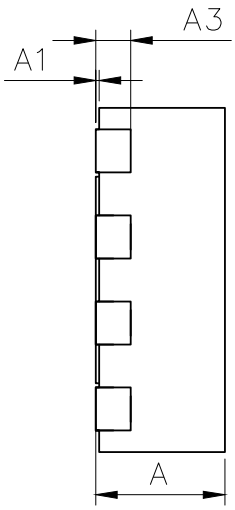
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

DFN2×2-8

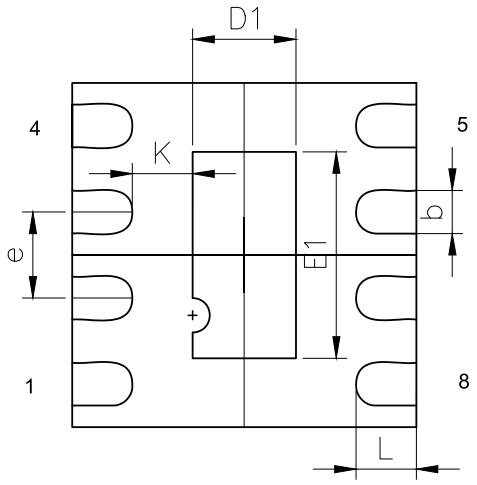
Package Outline Dimensions DF4(DFN2X2-8-A)



Top View



Side View



Bottom View

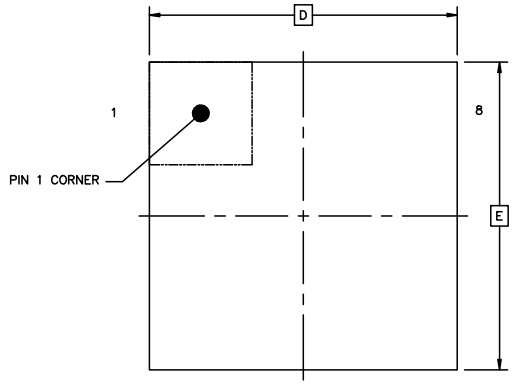
NOTES

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

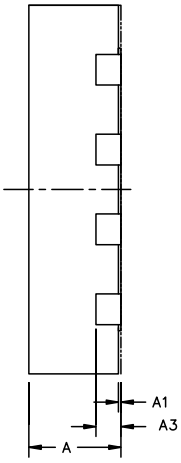
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
b	0.200	0.300	0.008	0.012
A3	0.150	0.250	0.006	0.010
D	1.900	2.100	0.075	0.083
D1	0.500	0.700	0.020	0.028
E	1.900	2.100	0.075	0.083
E1	1.100	1.300	0.043	0.051
e	0.500 BSC		0.020BSC	
L	0.274	0.426	0.011	0.017

DFN3×3-8

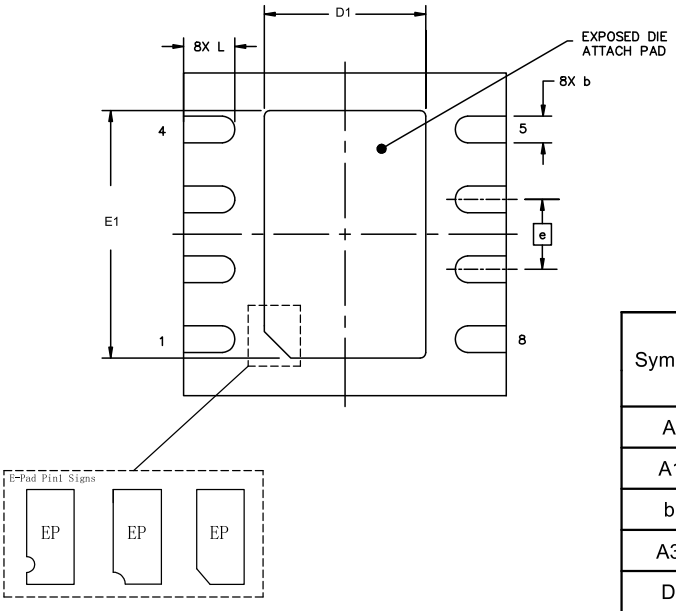
Package Outline Dimensions DF6(DFN3X3-8-A)



TOP VIEW



SIDE VIEW



BOTTOM VIEW

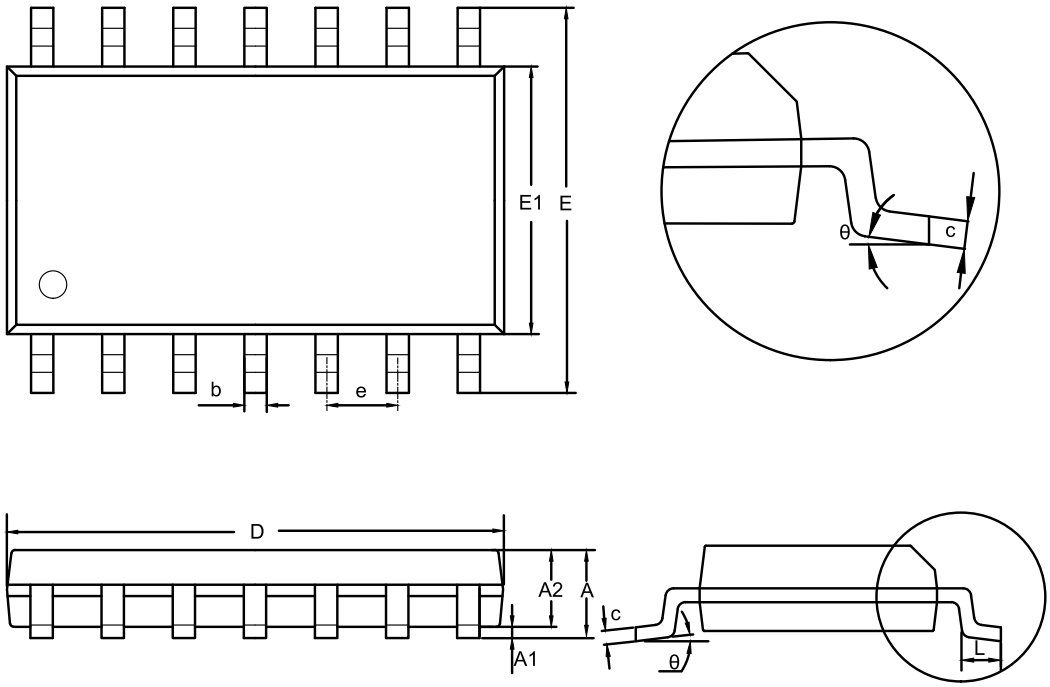
NOTES

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.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
b	0.200	0.350	0.008	0.014
A3	0.150	0.250	0.006	0.010
D	2.900	3.100	0.114	0.122
D1	1.400	1.600	0.055	0.063
E	2.900	3.100	0.114	0.122
E1	2.200	2.400	0.087	0.094
e	0.650 BSC		0.026 BSC	
L	0.224	0.575	0.009	0.023

SOP14

Package Outline Dimensions SO2(SOP-14-A)



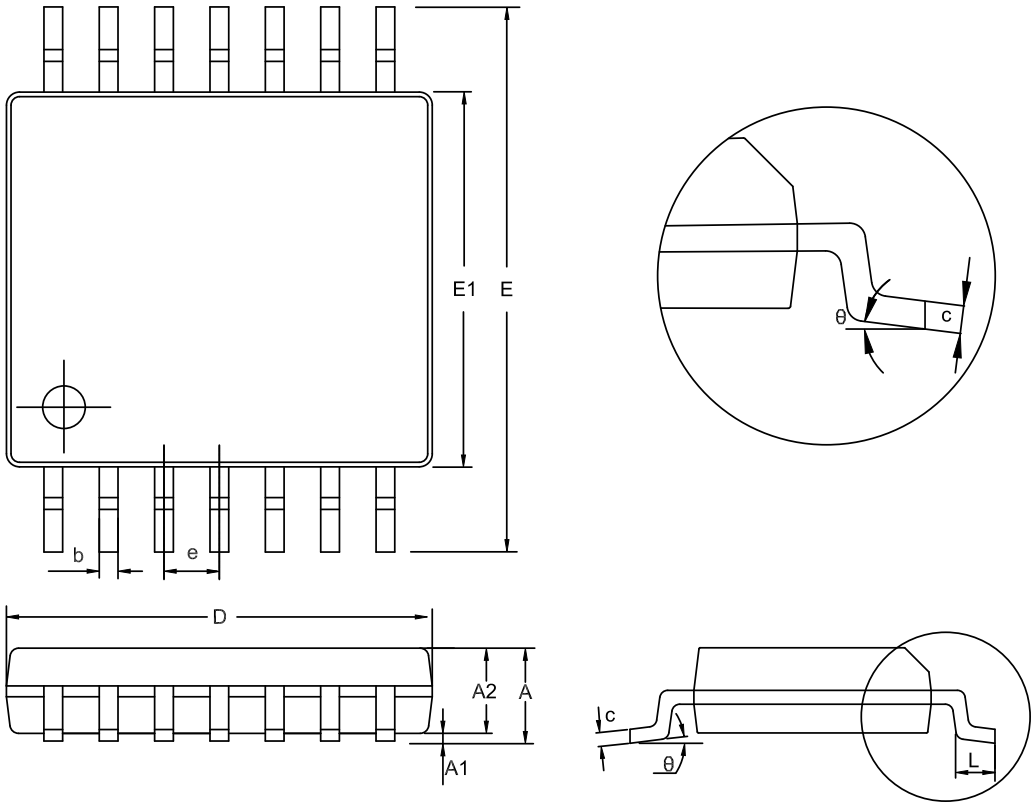
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.650	0.049	0.065
b	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D	8.450	8.850	0.333	0.348
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 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
TP2261-SR	−40 to 125°C	SOP8	2261	3	Tape and Reel, 4000	Green
TP2261-TR	−40 to 125°C	SOT23-5	226	3	Tape and Reel, 3000	Green
TP2262-SR	−40 to 125°C	SOP8	TP2262	3	Tape and Reel, 4000	Green
TP2262-FR (1)	−40 to 125°C	DFN2×2-8	226	3	Tape and Reel, 3000	Green
TP2262-F2R (1)	−40 to 125°C	DFN3×3-8	2262	3	Tape and Reel, 4000	Green
TP2262-TSR	−40 to 125°C	TSSOP8	2262	3	Tape and Reel, 3000	Green
TP2262-VR	−40 to 125°C	MSOP8	2262	3	Tape and Reel, 3000	Green
TP2264-SR	−40 to 125°C	SOP14	TP2264	3	Tape and Reel, 2500	Green
TP2264-TR	−40 to 125°C	TSSOP14	2264	3	Tape and Reel, 3000	Green

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

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

IMPORTANT NOTICE AND DISCLAIMER

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.