

### Features

- Supply Voltage: 4.5 V to 40 V or  $\pm 2.25$  V to  $\pm 20$  v
- Offset Voltage:  $\pm 30$   $\mu$ V Maximum
- Differential Input Voltage Range to Supply Rail, can Work as Comparator
- Input Rail to  $-V_S$ , Rail-to-Rail Output
- Drive Any Capacitive Load
- Bandwidth: 6 MHz, Slew Rate: 5 V/ $\mu$ s
- Excellent EMI Suppress Performance: 85 dB at 1 GHz
- Over-Temperature Protection
- Low Noise: 8 nV/ $\sqrt{\text{Hz}}$  at 1 kHz
- 2-kV HBM, 1-kV CDM, 500 mA Latch Up
- $-40^\circ\text{C}$  to  $125^\circ\text{C}$  Operation Temperature Range

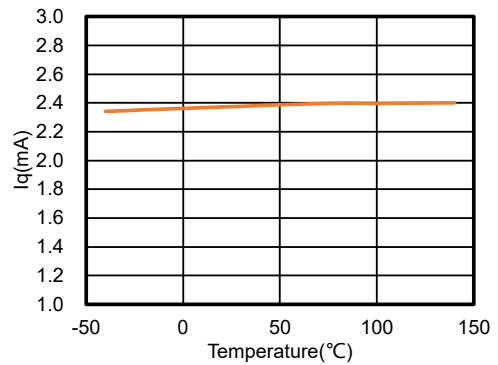
### Applications

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

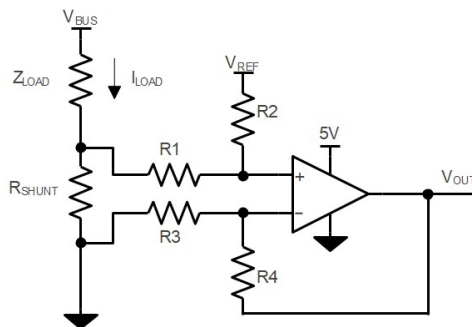
### Description

The TPA186x series of amplifiers are the newest high-supply voltage amplifiers with 30- $\mu$ V low offset, low noise, and stable high-frequency response. They incorporate 3PEAK’s proprietary and patented design techniques to achieve excellent AC performance with 6-MHz bandwidth, 5-V/ $\mu$ s slew rate, and low distortion while drawing only 1.4-mA quiescent current per amplifier. The input common-mode voltage range extends to  $V_-$ , and the outputs swing rail-to-rail.

The TPA186x has an over-temperature protection feature to guarantee chip safety. The output of the TPA186x will enter high impedance when the die temperature reaches around  $170^\circ\text{C}$  and will recover the function when the die temperature is down to around  $150^\circ\text{C}$ . The product has a very small power temperature coefficient, which is helpful to temperature-sensitive applications.



### Typical Application Circuit



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

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

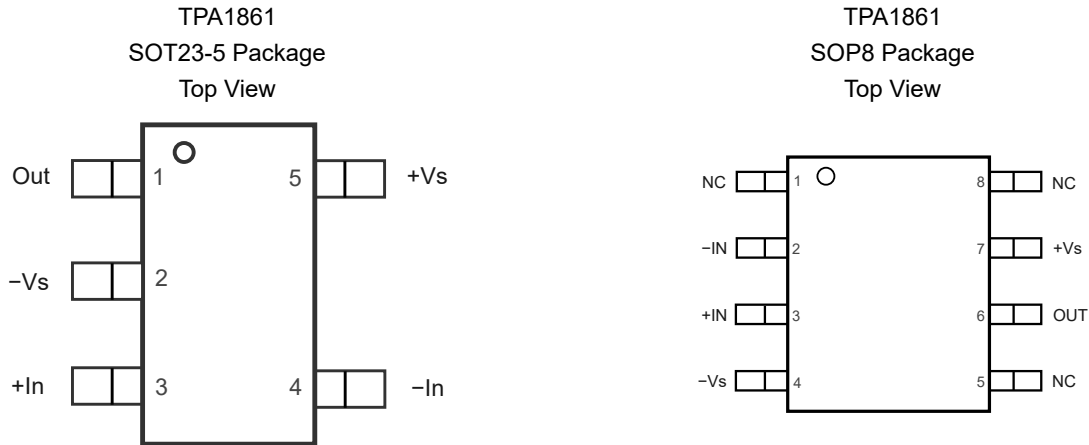
## Table of Contents

<b>Features</b> .....	1
<b>Applications</b> .....	1
<b>Description</b> .....	1
<b>Typical Application Circuit</b> .....	1
<b>Revision History</b> .....	3
<b>Pin Configuration and Functions</b> .....	4
<b>Specifications</b> .....	7
Absolute Maximum Ratings <sup>(1)</sup> .....	7
ESD, Electrostatic Discharge Protection.....	7
Recommended Operating Conditions.....	7
Thermal Information.....	8
Electrical Characteristics.....	9
Typical Performance Characteristics.....	11
<b>Detailed Description</b> .....	14
Overview.....	14
Functional Block Diagram.....	14
<b>Application and Implementation</b> .....	15
Application Information .....	15
<b>Tape and Reel Information</b> .....	16
<b>Package Outline Dimensions</b> .....	18
SOT23-5.....	18
SOP8.....	19
MSOP8.....	20
DFN3X3-8.....	21
SOP14.....	22
TSSOP14.....	23
<b>Order Information</b> .....	24
<b>IMPORTANT NOTICE AND DISCLAIMER</b> .....	25

## Revision History

Date	Revision	Notes
2019-09-10	Rev.0	Initial Version.
2019-11-27	Rev.0.01	Removed Part Number: TPA1862-TSR; Added Part Number: TPA1864-SR, TPA1864-TR.
2020-04-26	Rev.A	Added Test Figure.
2020-08-01	Rev.A.1	Added More Test Figures.
2020-11-06	Rev.A.2	Updated Test Figure: Iq vs. temperature, Vout vs. Iout.
2021-05-04	Rev.A.3	Added Tape and Reel Information.
2021-07-07	Rev.A.4	Updated maximum rating: Input voltage: $(-V_S) - 0.3$ to $(+V_S) + 0.3 \rightarrow (-V_S) - 0.3$ to 40 V Differential Input Voltage: $(+V_S) (-V_S) \rightarrow (-V_S) - (+V_S)$ to $(+V_S) - (-V_S)$ .
2022-08-18	Rev.A.5	Updated to new document format; Updated the working voltage to 40 V, the absolute rating voltage to 42 V; Added new package: TPA1862-DF7R.
2022-12-28	Rev.A.6	Updated to new document format.

## Pin Configuration and Functions

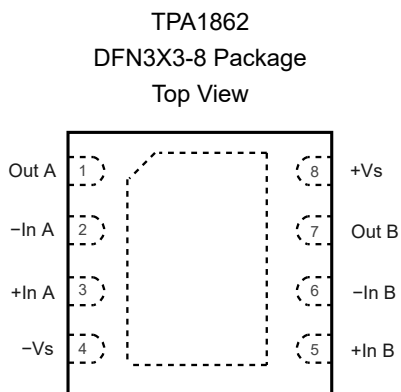
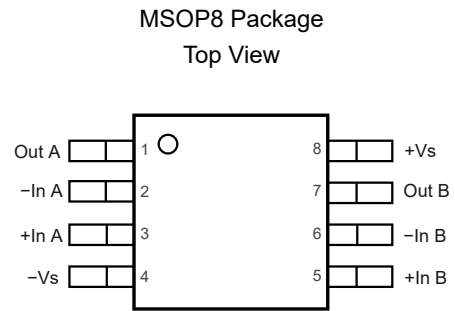
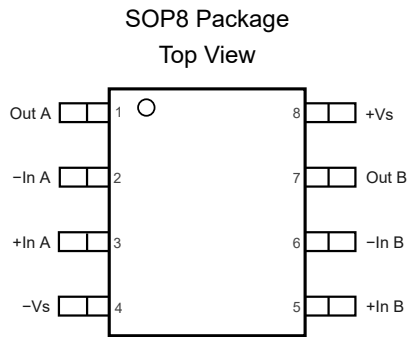


**Table 1. Pin Functions: TPA1861**

Pin		Name	I/O	Description
SOT23-5	SOP8			
1	6	Out	Output	Output
2	4	-Vs		Negative power supply
3	3	+In	Input	Noninverting input
4	2	-In	Input	Inverting input
5	7	+Vs		Positive power supply
	1	NC		Not connected
	5	NC		Not connected
	8	NC		Not connected

TPA1862

TPA1862

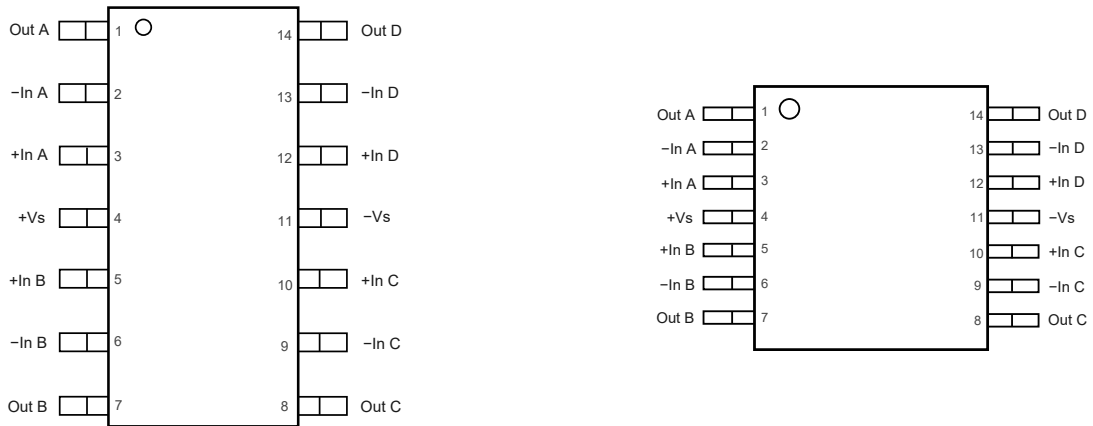


**Table 2. Pin Functions: TPA1862**

Pin			Name	I/O	Description
SOP8	MSOP8	DFN3X3-8			
	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

TPA1864  
SOP14 Package  
Top View

TPA1864  
TSSOP14 Package  
Top View



**Table 3. Pin Functions: TPA1864**

Pin		Name	I/O	Description
SOP14	TSSOP14			
1	1	Out A	Output	Output
2	2	-In A	Input	Inverting input
3	3	+In A	Input	Noninverting input
4	4	+VS		Positive power supply
5	5	+In B	Input	Noninverting input
6	6	-In B	Input	Inverting input
7	7	Out B	Output	Output
8	8	Out C	Output	Output
9	9	-In C	Input	Inverting input
10	10	+In C	Input	Noninverting input
11	11	-VS		Negative power supply
12	12	+In D	Input	Noninverting input
13	13	-In D	Input	Inverting input
14	14	Out D	Output	Output

## Specifications

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

All test conditions: Over operating ambient temperature, unless otherwise noted.

Parameter		Min	Max	Unit
	Supply Voltage, (+V <sub>S</sub> ) - (-V <sub>S</sub> )		42 V	V
	Input Voltage	(-V <sub>S</sub> ) - 0.3	42 V	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 Voltage	(-V <sub>S</sub> ) - 0.3	(+V <sub>S</sub> ) + 0.3	V
	Output Short-Circuit Duration <sup>(3)</sup>		Infinite	
T <sub>J</sub>	Maximum Operating 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 are protected by ESD protection diodes to the negative power supply. If the input extends to more than 300 mV beyond the negative 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 <sup>(1)</sup>	ANSI/ESDA/JEDEC JS-001	2	kV
CDM	Charged Device Model ESD <sup>(2)</sup>	ANSI/ESDA/JEDEC JS-002	1	kV

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V <sub>S</sub>	Supply Voltage, (+V <sub>S</sub> ) - (-V <sub>S</sub> )	4.5 or ±2.25		40 or ±20	V
T <sub>A</sub>	Operating Temperature Range	-40		125	°C

**Thermal Information**

Package Type	$\theta_{JA}$	$\theta_{JC}$	Unit
SOT23-5	250	81	°C/W
SOP8	158	43	°C/W
MSOP8	210	45	°C/W
SOP14	120	36	°C/W
TSSOP14	180	35	°C/W



## Electrical Characteristics

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

Parameter		Conditions	$T_A$	Min	Typ	Max	Unit	
<b>Power Supply</b>								
$V_S$	Supply Voltage Range			4.5 or $\pm 2.25$		40 or $\pm 20$	V	
$I_Q$	Quiescent Current per Amplifier	$V_S = 40\text{ V}$			1.6	2	mA	
		$V_S = 30\text{ V}$			1.4	1.6	mA	
			$-40^\circ\text{C to }125^\circ\text{C}$			1.8	mA	
		$V_S = 5\text{ V}$			1.2	1.5	mA	
		$-40^\circ\text{C to }125^\circ\text{C}$			1.7	mA		
PSRR	Power Supply Rejection Ratio	$V_S = 4.5\text{ V to }36\text{ V}$		125	140		dB	
			$-40^\circ\text{C to }125^\circ\text{C}$	120			dB	
<b>Input Characteristics</b>								
$V_{OS}$	Input Offset Voltage	$V_S = 40\text{ V}, V_{CM} = 20\text{ V}$		-30		30	$\mu\text{V}$	
		$V_S = 30\text{ V}, V_{CM} = 15\text{ V}$		-30		30	$\mu\text{V}$	
			$-40^\circ\text{C to }125^\circ\text{C}$	-50		50	$\mu\text{V}$	
		$V_S = 5\text{ V}, V_{CM} = 2.5\text{ V}$		-30		30	$\mu\text{V}$	
		$-40^\circ\text{C to }125^\circ\text{C}$	-50		50	$\mu\text{V}$		
$V_{OSTC}$	Input Offset Voltage Drift		$-40^\circ\text{C to }125^\circ\text{C}$		0.01	0.2	$\mu\text{V}/^\circ\text{C}$	
$I_B$	Input Bias Current				100		pA	
			$-40^\circ\text{C to }125^\circ\text{C}$		100		pA	
$I_{OS}$	Input Offset Current				100		pA	
$I_{IN}$	Different Input Current	$V_S = 36\text{ V}, V_{ID} = 36\text{ V}$			10	100	$\mu\text{A}$	
			$-40^\circ\text{C to }125^\circ\text{C}$			120	$\mu\text{A}$	
$C_{IN}$	Input Capacitance	Differential Mode			5		pF	
		Common Mode			2.5		pF	
$A_v$	Open-loop Voltage Gain	$R_{LOAD} = 10\text{ k}\Omega,$ $V_{OUT} = 0.5\text{ V to }29.5\text{ V}$		130	140		dB	
			$-40^\circ\text{C to }125^\circ\text{C}$	125			dB	
$V_{CMR}$	Common-mode Input Voltage Range			(V-)		(V+) - 1.5	V	
CMRR	Common Mode Rejection Ratio	$V_{CM} = 0\text{ V to }28.5\text{ V}$		125	140		dB	
			$-40^\circ\text{C to }125^\circ\text{C}$	120			dB	
<b>Output Characteristics</b>								
	Output Swing from Positive Rail	$R_{LOAD} = 100\text{ k}\Omega\text{ to }V_S/2$			10	15	mV	
				$-40^\circ\text{C to }125^\circ\text{C}$			30	mV
						75	100	mV

Parameter		Conditions	T <sub>A</sub>	Min	Typ	Max	Unit	
			-40°C to 125°C			180	mV	
		R <sub>LOAD</sub> = 2 kΩ to V <sub>S</sub> /2			400	500	mV	
			-40°C to 125°C				750	mV
Output Swing from Negative Rail	R <sub>LOAD</sub> = 100 kΩ to V <sub>S</sub> /2				3	5	mV	
		-40°C to 125°C				10	mV	
	R <sub>LOAD</sub> = 10 kΩ to V <sub>S</sub> /2				25	35	mV	
		-40°C to 125°C					60	mV
	R <sub>LOAD</sub> = 2 kΩ to V <sub>S</sub> /2				130	150	mV	
		-40°C to 125°C					300	mV
I <sub>sc</sub>	Source			60	95		mA	
		-40°C to 85°C		40			mA	
		-40°C to 125°C		35			mA	
	Sink				130	150		mA
		-40°C to 85°C		100			mA	
		-40°C to 125°C		85			mA	
	Capacitive Load Drive				1		nF	
<b>AC Specifications</b>								
GBW	Gain-Bandwidth Product				6		MHz	
SR	Slew Rate	G = 1, 10 V step		3	5		V/μs	
			-40°C to 125°C	2.2			V/μs	
t <sub>OR</sub>	Overload Recovery				500		ns	
t <sub>s</sub>	Settling Time, 0.1%	G = 1, 10 V step			7		μs	
	Settling Time, 0.01%				12		μs	
PM	Phase Margin	R <sub>L</sub> = 10 K, C <sub>L</sub> = 100 pF			70		°	
GM	Gain Margin	R <sub>L</sub> = 10 K, C <sub>L</sub> = 100 pF			15		dB	
<b>Noise Performance</b>								
E <sub>N</sub>	Input Voltage Noise	f = 0.1 Hz to 10 Hz			0.1		μV <sub>PP</sub>	
e <sub>N</sub>	Input Voltage Noise Density	f = 0.1 Hz			8		nV/√Hz	
		f = 1 kHz			8		nV/√Hz	
		f = 10 kHz			10		nV/√Hz	
		f = 100 kHz			20		nV/√Hz	
i <sub>N</sub>	Input Current Noise	f = 10 kHz			200		fA/√Hz	
THD+N	Total Harmonic Distortion and Noise	f = 1 kHz, G = 1, R <sub>L</sub> = 10 kΩ, V <sub>OUT</sub> = 6 V <sub>RMS</sub>			0.0005		%	

### Typical Performance Characteristics

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

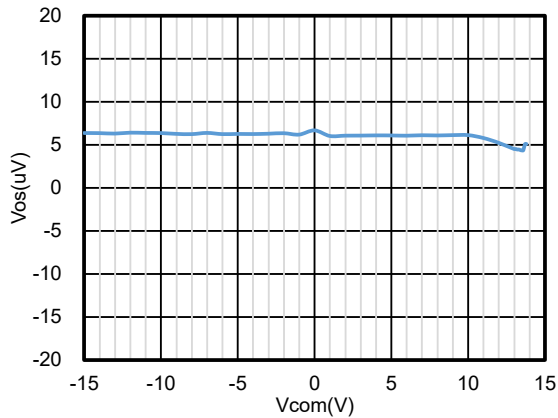


Figure 1. Offset Voltage vs. Common-Mode Voltage

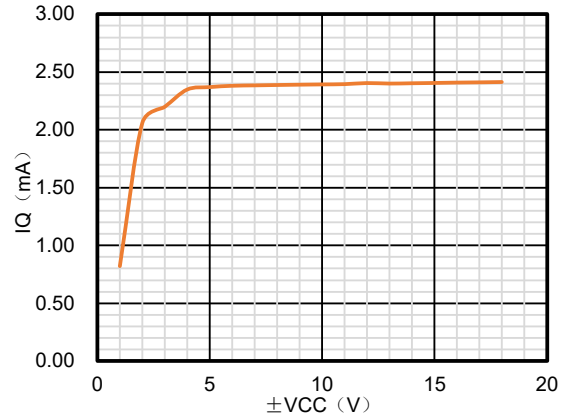


Figure 2. Iq vs. Supply Voltage

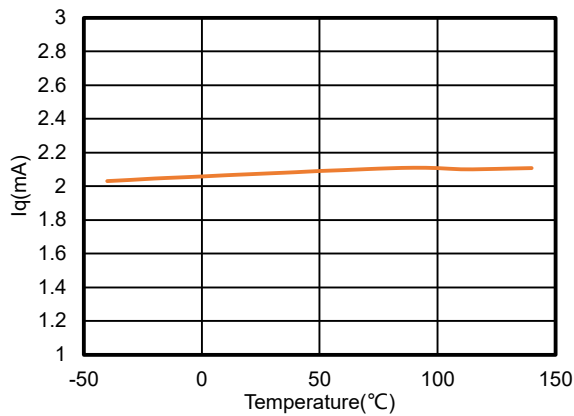


Figure 3. Iq vs. Temperature, +2.5 V Supply, TPA1862

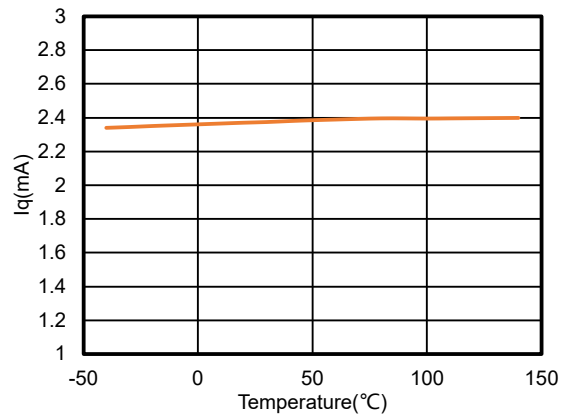


Figure 4. Iq vs. Temperature, +15 V Supply, TPA1862

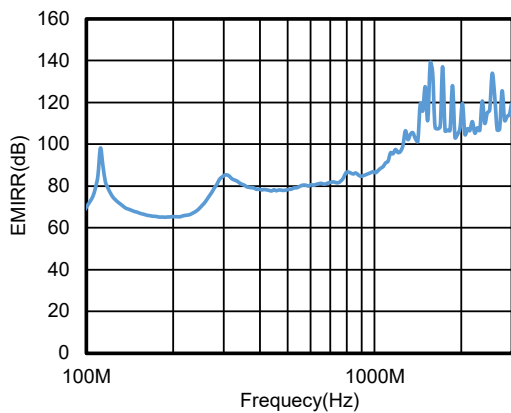


Figure 5. EMIRR vs. Frequency

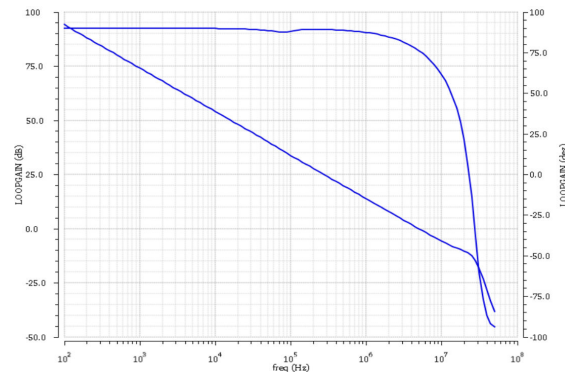


Figure 6. Open Loop Gain and Phase vs. Frequency  $R_L = 10\text{ k}\Omega$ ,  $C_L = 50\text{ pF}$

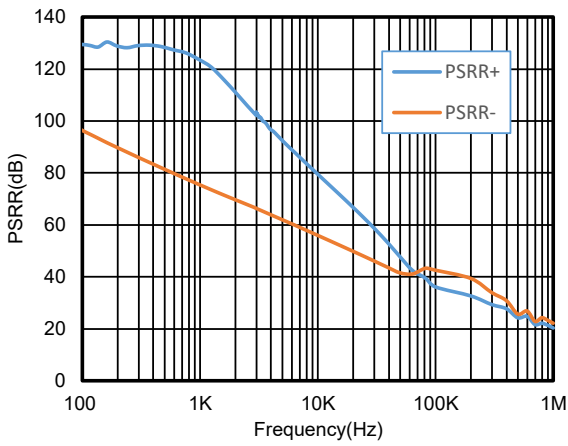


Figure 7. PSRR vs. Frequency

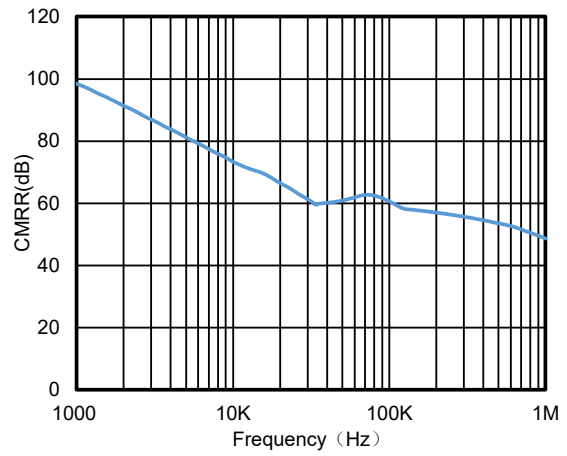
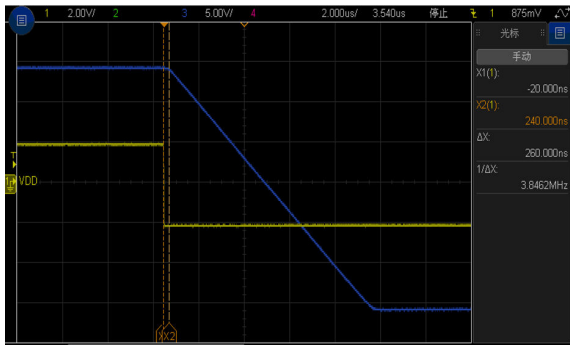
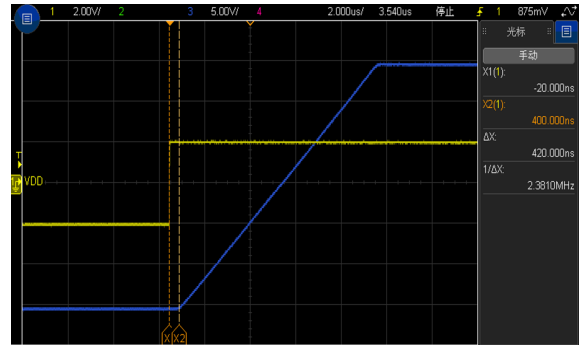


Figure 8. CMRR vs. Frequency



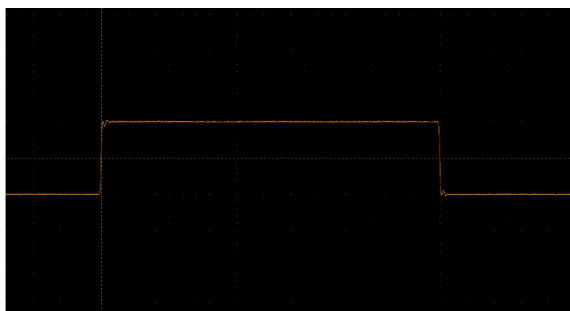
Time: 2 us/div, Measure Time: 260 ns  
 $R_L = 2\text{ K}$ ,  $C_L = 100\text{ pF}$ ,  $G = 10$

Figure 9. Positive Overload Recovery



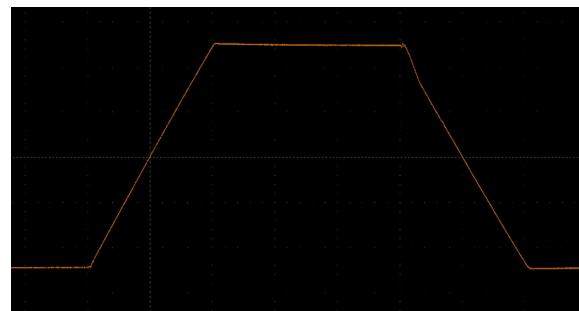
Time: 2 us/div, Measure Time: 420 ns  
 $R_L = 2\text{ K}$ ,  $C_L = 100\text{ pF}$ ,  $G = 10$

Figure 10. Negative Overload Recovery



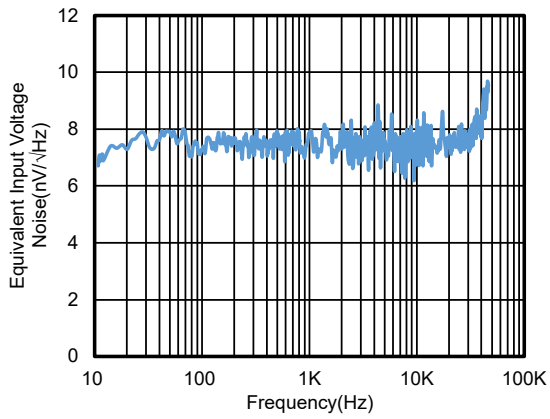
Voltage: 50 mV/div, Time: 2 us/div  
 $R_L = 2\text{ K}$ ,  $C_L = 100\text{ pF}$ ,  $G = 1$

Figure 11. 100-mV Signal Step Response

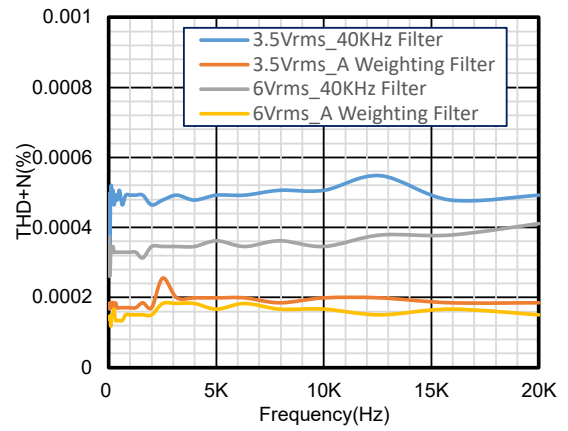


Voltage: 2 V/div, Time: 2 μs/div  
 $R_L = 2\text{ K}$ ,  $C_L = 100\text{ pF}$ ,  $G = 1$

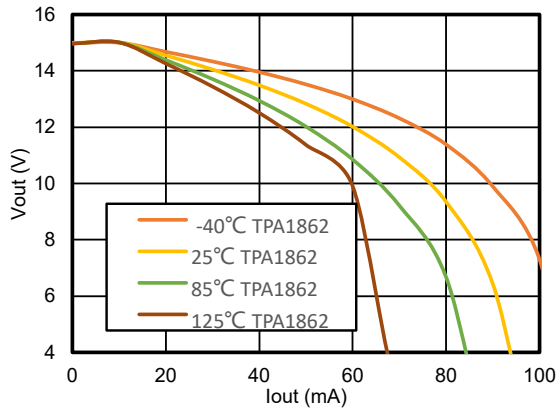
Figure 12. 10-V Signal Step Response



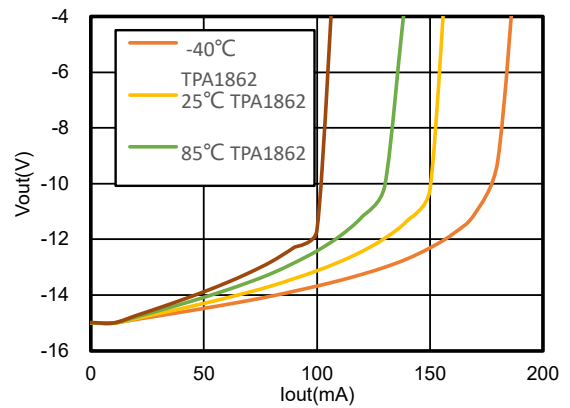
**Figure 13. Voltage Noise Density vs. Frequency**



**Figure 14. THD vs. Frequency, G = 1**



**Figure 15. V<sub>OUT</sub> vs. I<sub>OUT</sub>, Source**



**Figure 16. V<sub>OUT</sub> vs. I<sub>OUT</sub>, Sink**

## Detailed Description

### Overview

The TPA186x series op amps can operate on a single-supply voltage (4.5 V to 40 V), or a split-supply voltage ( $\pm 2.25$  V to  $\pm 20$  V), making them highly versatile and easy to use. The power-supply pins should have local bypass ceramic capacitors (typically 0.01  $\mu$ F to 0.1  $\mu$ F). Parameters that can exhibit variance with regard to operating voltage or temperature are presented in the [Typical Performance Characteristics](#).

### Functional Block Diagram

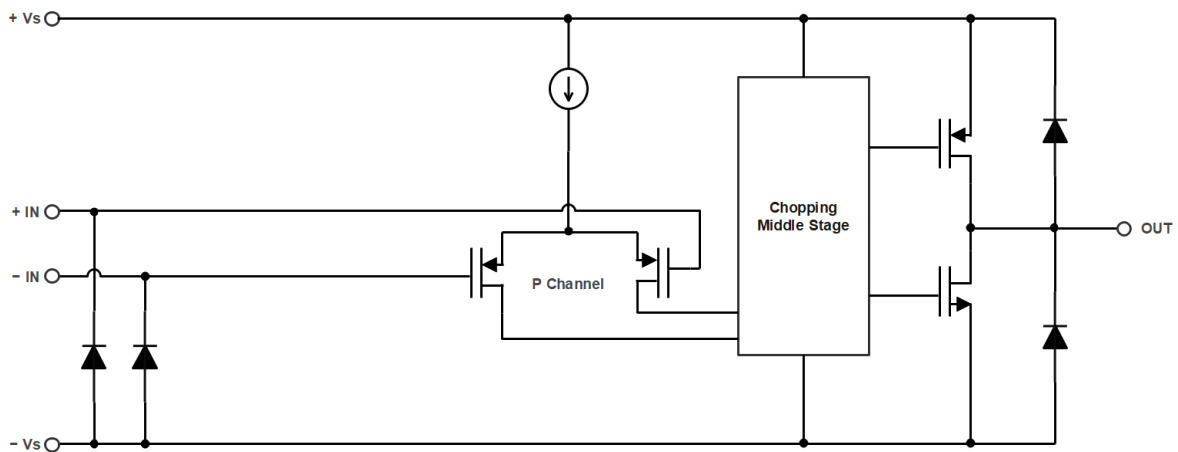


Figure 17. Functional Block Diagram

## Application and Implementation

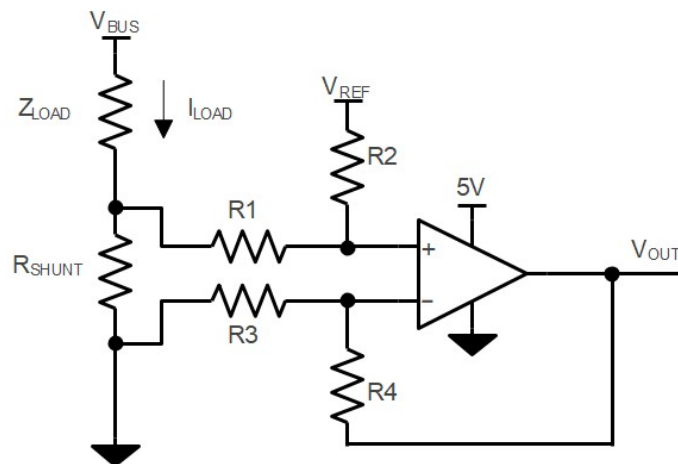
### Note

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 Side Current Sensing Application

Figure 18 shows the device configured in a low-side current sensing application. The low-side current sensing method consists of placing a sense resistor between the load and the circuit ground. The voltage dropping across the resistor is amplified by different amplifier circuits with the device. The  $V_{REF}$  can be used to add bias voltage to the output voltage. Particular attention must be paid to the matching and precision of R1, R2, R3, and R4, to maximize the accuracy of the measurement.



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

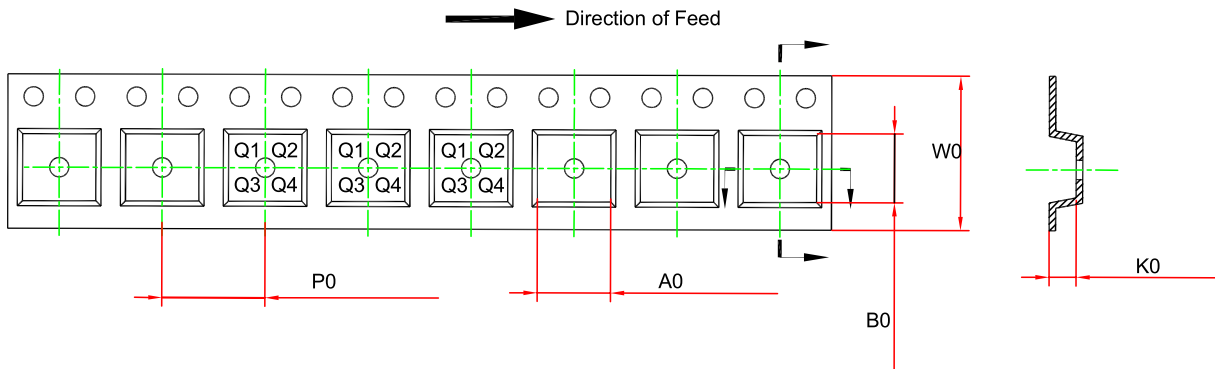
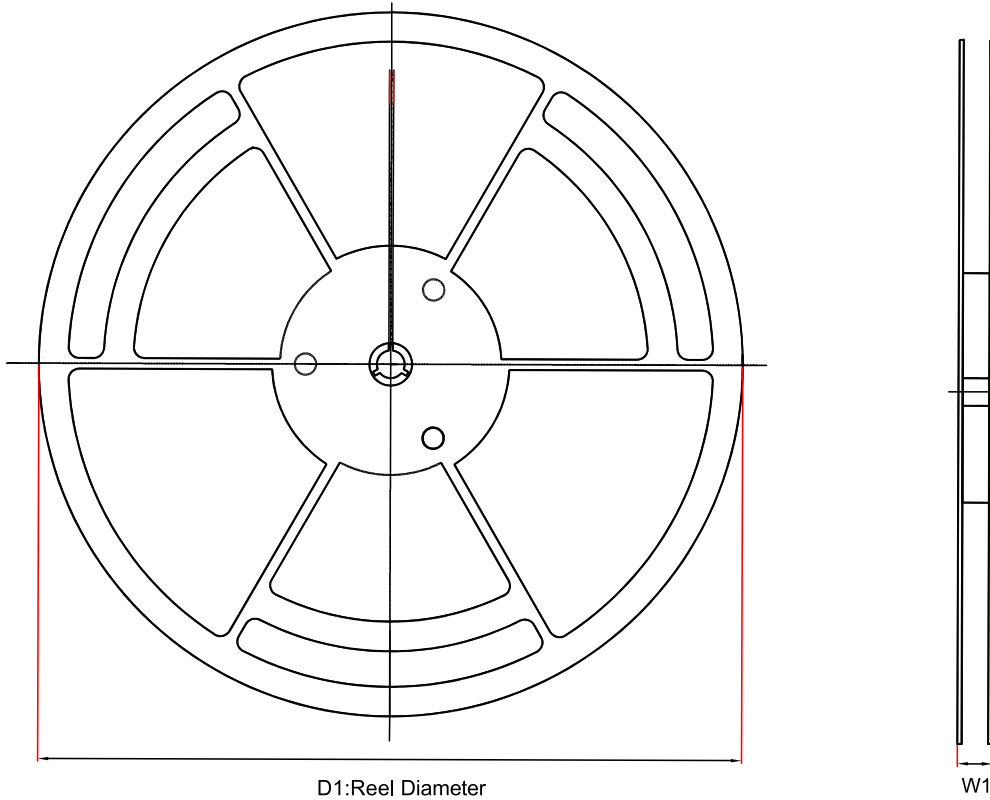
$$\text{When } R3 = R1, R2 = R4, R_{SHUNT} \ll R1$$

Figure 18. Low-Side Current Sensing Application

### Power Supply Recommendations

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

### Tape and Reel Information



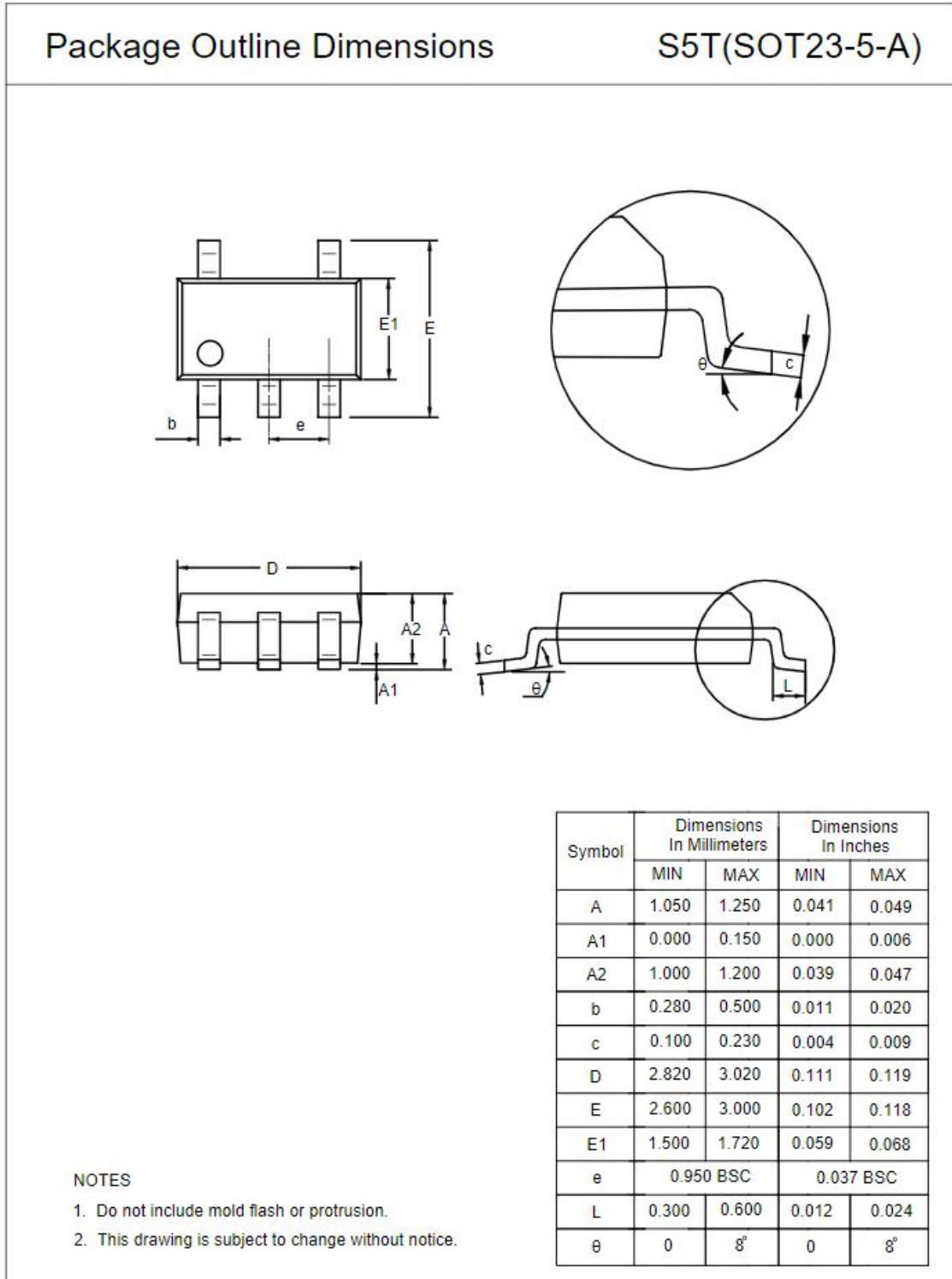
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA1861-TR	SOT23-5	180.0	13.1	3.2	3.2	1.4	4.0	8.0	Q3
TPA1861-SR	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TPA1862-SR	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TPA1862-VR	MSOP8	330.0	17.6	5.2	3.3	1.5	8.0	12.0	Q1
TPA1862-DF7R	DFN3X3-8	330.0	17.6	3.4	3.4	1.1	8.0	12.0	Q2



Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA1864-SR	SOP14	330.0	21.6	6.5	9.0	2.1	8.0	16.0	Q1
TPA1864-TR	TSSOP14	330.0	17.6	6.8	5.4	1.2	8.0	12.0	Q1

## Package Outline Dimensions

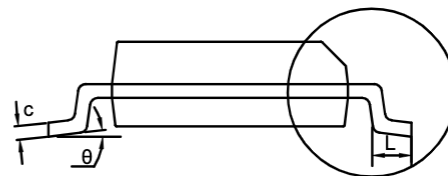
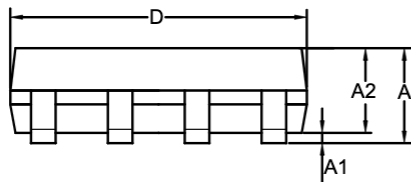
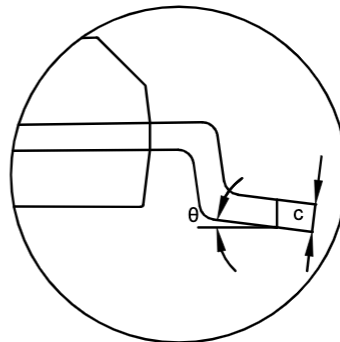
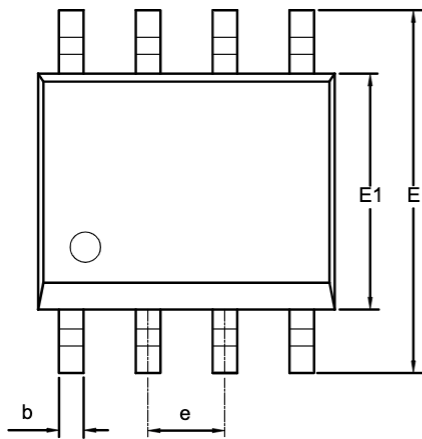
SOT23-5



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°

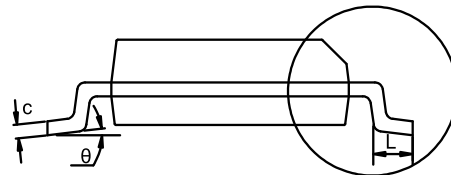
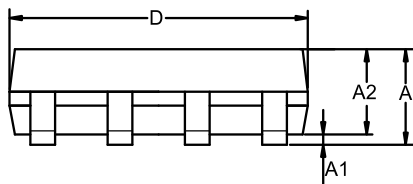
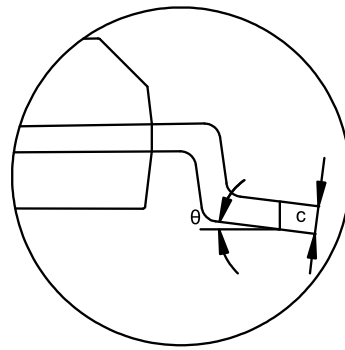
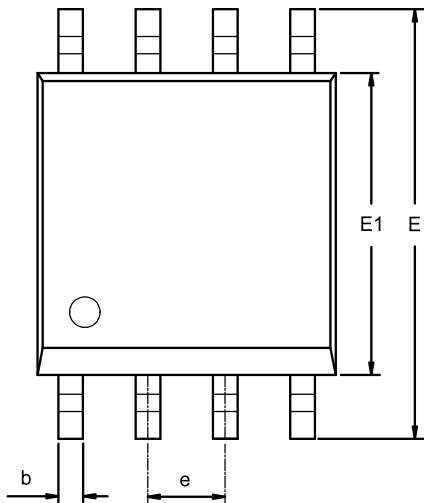
NOTES

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

MSOP8

Package Outline Dimensions

VS1(MSOP-8-A)

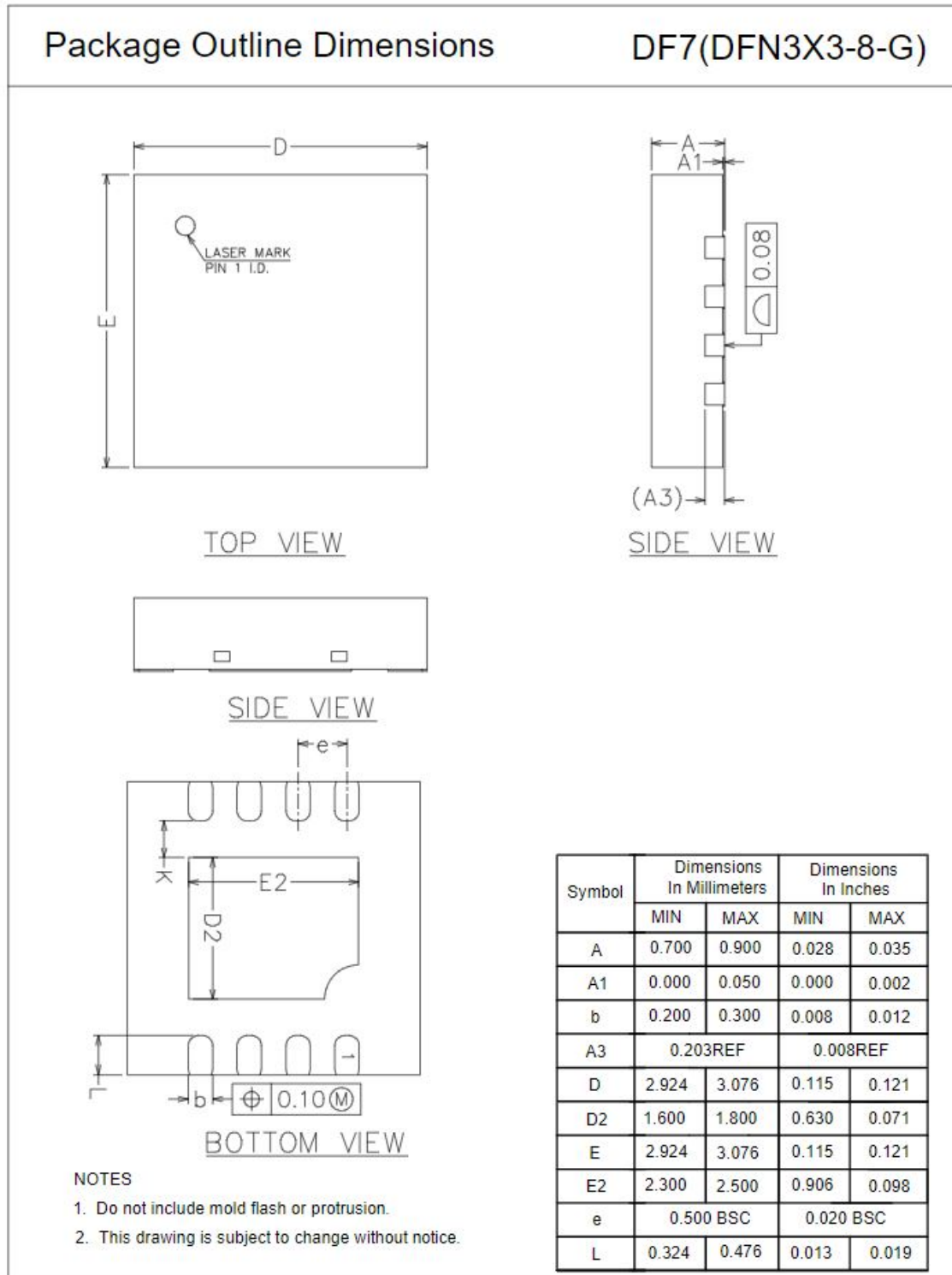


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.650 BSC		0.026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

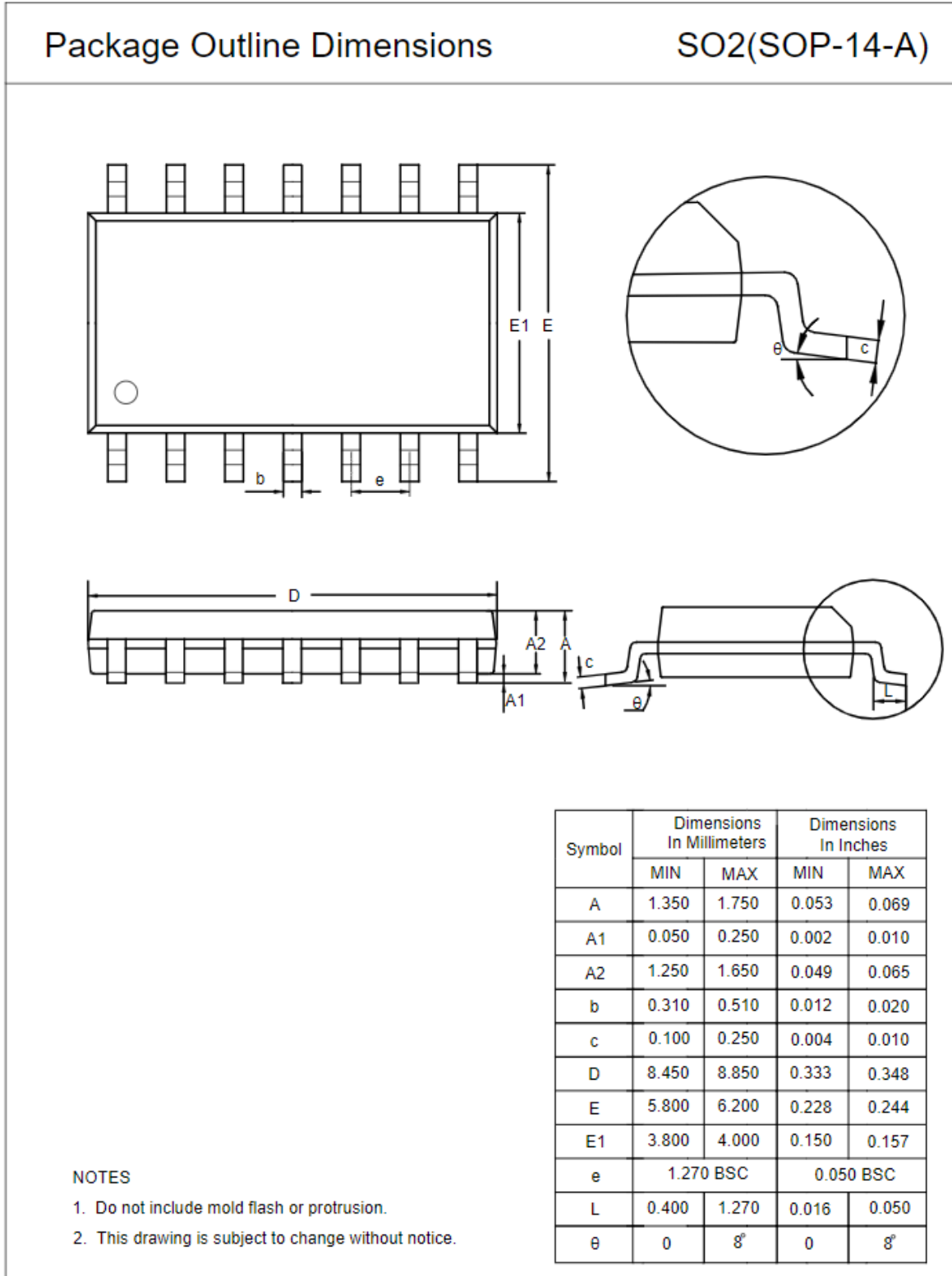
NOTES

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

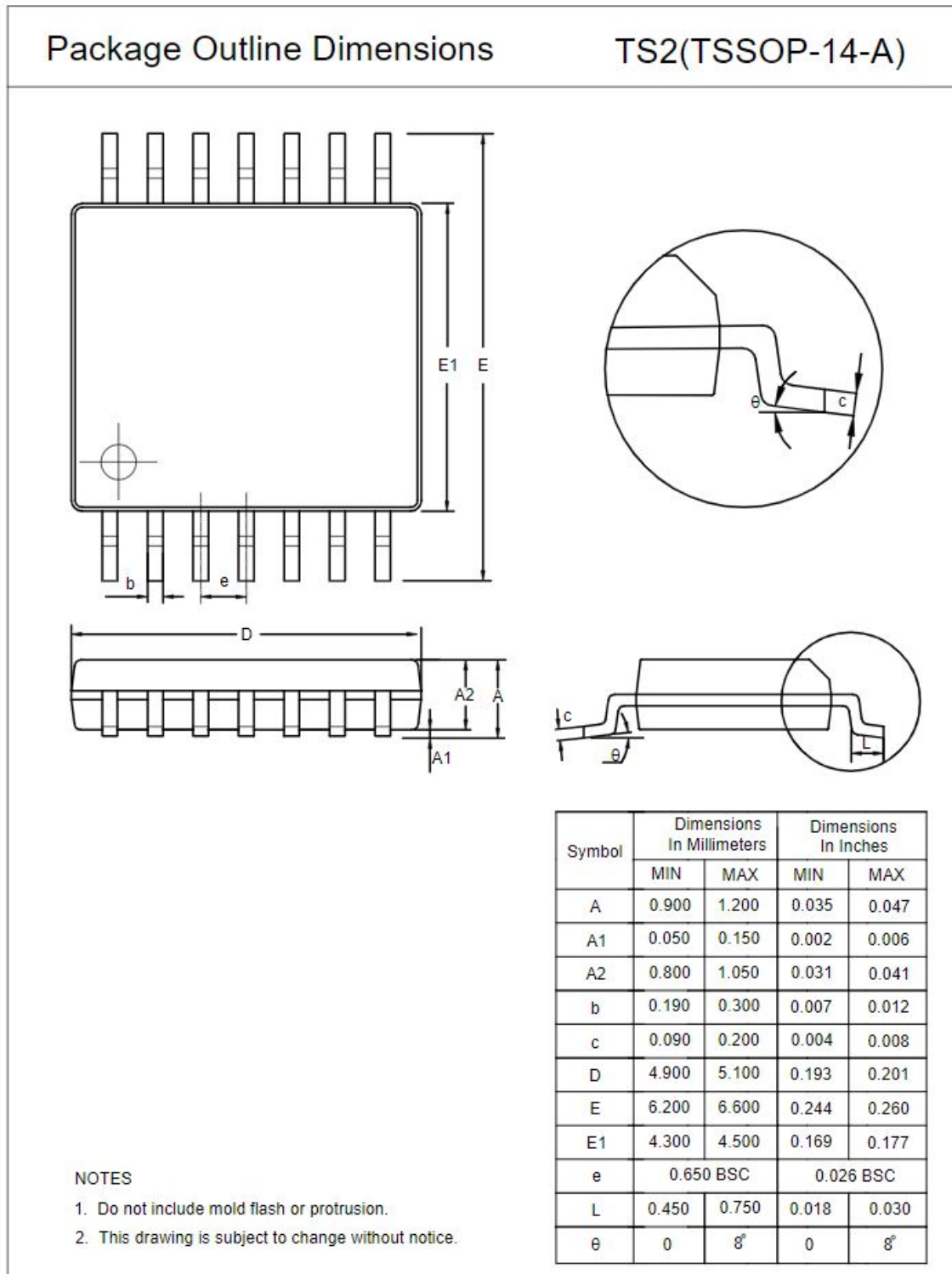
DFN3X3-8



SOP14



TSSOP14



## Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPA1861-SR	-40 to 125°C	SOP8	1861	3	Tape and Reel, 4000	Green
TPA1861-TR	-40 to 125°C	SOT23-5	A86	3	Tape and Reel, 3000	Green
TPA1862-SR	-40 to 125°C	SOP8	1862	3	Tape and Reel, 4000	Green
TPA1862-VR	-40 to 125°C	MSOP8	1862	3	Tape and Reel, 3000	Green
TPA1862-DF7R	-40 to 125°C	DFN3X3-8	A1862	3	Tape and Reel, 4000	Green
TPA1864-SR	-40 to 125°C	SOP14	1864	3	Tape and Reel, 2500	Green
TPA1864-TR	-40 to 125°C	TSSOP14	1864	3	Tape and Reel, 3000	Green

(1) For future products, 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

**Copyright**© 3PEAK 2012-2023. 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.

This page intentionally left blank