

### Features

- Supply Voltage: 4.5 V to 40 V or  $\pm 2.25$  V to  $\pm 20$  V
- Offset Voltage:  $\pm 15$   $\mu$ V (Max)
- Differential Input Voltage Range to Supply Rail, can Work as Comparator
- Input Rail to  $-V_S$ , Rail-to-Rail Output
- Bandwidth: 12 MHz
- Slew Rate: 12 V/ $\mu$ s
- Over-Temperature Protection
- Low Noise: 6 nV/ $\sqrt{\text{Hz}}$  at 1 kHz
- 2-kV HBM, 1-kV CDM
- Operating Temperature Range:  $-40^\circ\text{C}$  to  $125^\circ\text{C}$

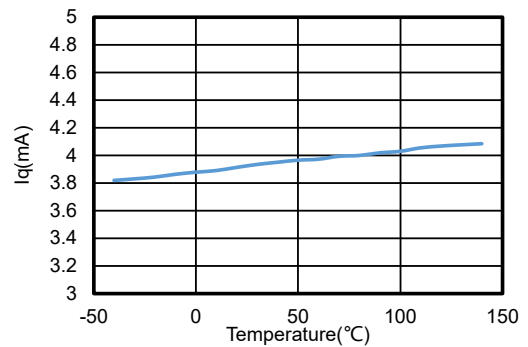
### Applications

- Instrumentation
- Active Filters, ASIC Input or Output Amplifiers
- Sensor Interface
- Motor Control
- Industrial Control
- Low Noise Power Supply

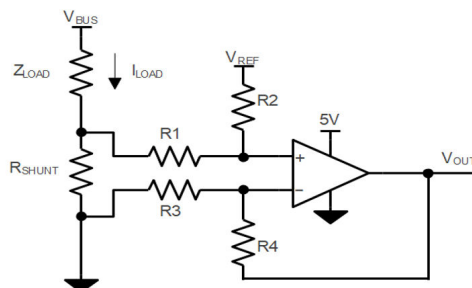
### Description

The TPA188x is a series of the newest high-supply voltage amplifiers with 15- $\mu$ V low offset, low noise, and stable high-frequency response. The TPA188x series incorporates proprietary and patented design techniques of 3PEAK to achieve excellent AC performance with 12-MHz bandwidth, 12-V/ $\mu$ s slew rate, and low distortion while drawing only 2000  $\mu$ A of quiescent current per amplifier. The input common-mode voltage range extends to  $-V_S$ , and the output swings rail-to-rail.

The TPA188x amplifiers have an over-temperature protection feature to guarantee chip safety. The outputs of the TPA188x series enter high impedance when the die temperature reaches around  $170^\circ\text{C}$ , and recover the function when the die temperature is down to around  $150^\circ\text{C}$ . These products have a very small power temperature coefficient, which is helpful for temperature-sensitive applications.



### Typical Application Circuit



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

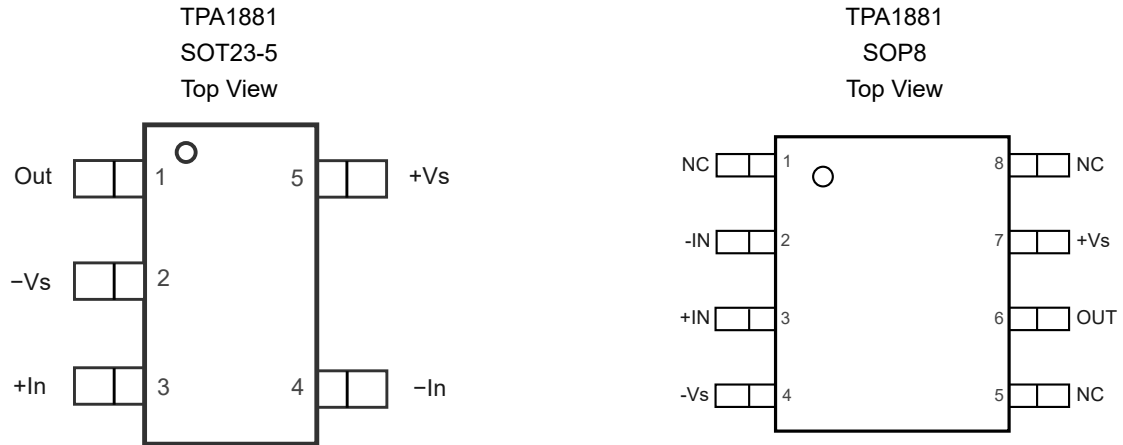
When  $R3 = R1$ ,  $R2 = R4$ ,  $R_{SHUNT} \ll R1$

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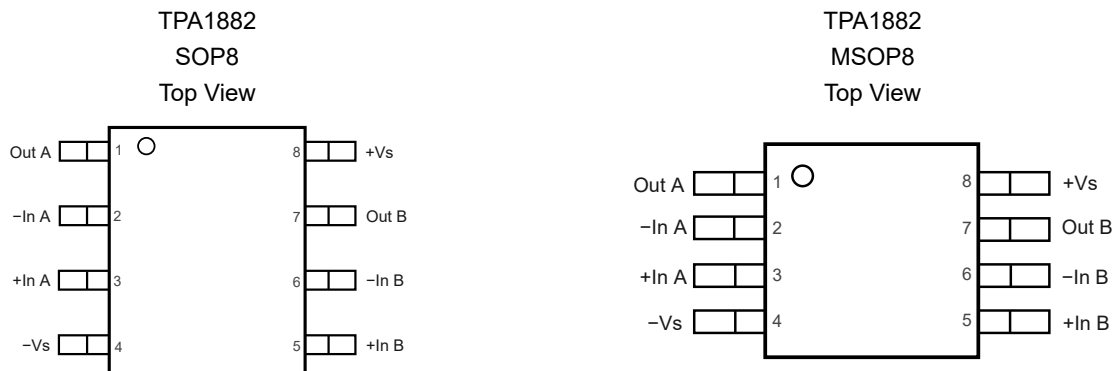
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## Revision History

Date	Revision	Notes
2019-01-10	Rev.Pre.0	Pre-released version.
2020-05-19	Rev.A.0	Initial version.
2020-08-03	Rev.A.1	Added test figures.
2020-11-06	Rev.A.2	Updated test figures: $I_Q$ vs. Temperature, $V_{OUT}$ vs. $I_{OUT}$ .
2021-07-07	Rev.A.3	Updated Absolute Maximum Ratings: <ul style="list-style-type: none"><li>• Updated the maximum value of Input Voltage: from <math>(+V_S) + 0.3</math> to 40 V.</li><li>• Updated the minimum value of Differential Input Voltage: <math>(+V_S)</math> to <math>(-V_S) - (+V_S)</math>.</li><li>• Updated the maximum value of Differential Input Voltage: <math>(-V_S)</math> to <math>(+V_S) - (-V_S)</math>.</li></ul>
2022-08-18	Rev.A.4	Updated the Package Outline Dimensions format. Updated the working voltage to 40 V, and the Absolute Rating Voltage to 42 V.
2023-06-01	Rev.A.5	Updated the website address. Updated the working voltage description. Added the dual-supply description.
2024-12-18	Rev.A.6	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.
2025-04-18	Rev.A.7	Corrected handwriting errors.
2025-05-20	Rev.A.8	Corrected typos for the titles of <a href="#">Figure 10</a> and <a href="#">Figure 16</a> .

**Pin Configuration and Functions**

**Table 1. Pin Functions: TPA1881**

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

**40-V, 12-MHz, Zero-Drift Operational Amplifier**

**Table 2. Pin Functions: TPA1882**

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 <sub>S</sub>		Negative power supply
5	+In B	I	Non-inverting input
6	-In B	I	Inverting input
7	Out B	O	Output
8	+V <sub>S</sub>		Positive power supply

## 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
	Input Voltage	(–V <sub>S</sub> ) – 0.3	42	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 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 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. 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 <sup>(1)</sup>	2	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 <sup>(2)</sup>	1	kV
LU	Latch Up	JESD 78, 25°C	500	mA
		JESD 78, 125°C	200	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.

### Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V <sub>S</sub>	Supply Voltage, (+V <sub>S</sub> ) – (–V <sub>S</sub> )	4.5 (±2.25)		40 (±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

**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		40	V
$I_Q$	Quiescent Current per Amplifier	$V_S = 40\text{ V}$			2.4	3	mA
		$V_S = 30\text{ V}$			2	2.5	mA
			$-40^\circ\text{C to }125^\circ\text{C}$			2.7	mA
		$V_S = 5\text{ V}$				1.9	2.4
$-40^\circ\text{C to }125^\circ\text{C}$					2.6	mA	
PSRR	Power Supply Rejection Ratio	$V_S = 4.5\text{ V to }36\text{ V}$		135	155		dB
			$-40^\circ\text{C to }125^\circ\text{C}$	130			dB
<b>Input Characteristics</b>							
$V_{OS}$	Input Offset Voltage	$V_S = 40\text{ V}, V_{CM} = 20\text{ V}$		-15		15	$\mu\text{V}$
		$V_S = 30\text{ V}, V_{CM} = 15\text{ V}$		-15		15	$\mu\text{V}$
			$-40^\circ\text{C to }125^\circ\text{C}$	-25		25	$\mu\text{V}$
		$V_S = 5\text{ V}, V_{CM} = 2.5\text{ V}$		-15		15	$\mu\text{V}$
$-40^\circ\text{C to }125^\circ\text{C}$	-25			25	$\mu\text{V}$		
$V_{OS\ TC}$	Input Offset Voltage Drift		$-40^\circ\text{C to }125^\circ\text{C}$		0.05	0.15	$\mu\text{V}/^\circ\text{C}$
$I_B$	Input Bias Current				10		pA
			$-40^\circ\text{C to }125^\circ\text{C}$		100		pA
$I_{OS}$	Input Offset Current				100		pA
$I_{IN}$	Differential Input Current	$V_S = 36\text{ V}, V_{ID} = 36\text{ V}$				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	
$A_V$	Open-Loop Voltage Gain	$R_{LOAD} = 10\text{ k}\Omega,$ $V_{OUT} = 0.5\text{ V to }29.5\text{ V}$		135	155		dB
			$-40^\circ\text{C to }125^\circ\text{C}$	130			dB
$V_{CMR}$	Common-Mode Input Voltage Range			$(-V_S)$		$(+V_S)$ $-1.5$	V
CMRR	Common-Mode Rejection Ratio	$V_{CM} = 0\text{ V to }28.5\text{ V}$		135	155		dB
			$-40^\circ\text{C to }125^\circ\text{C}$	130			dB
<b>Output Characteristics</b>							
	Output Swing from Positive Rail	$R_{LOAD} = 100\text{ k}\Omega\text{ to }V_S / 2$			12	25	mV
			$-40^\circ\text{C to }85^\circ\text{C}$			35	mV
			$-40^\circ\text{C to }125^\circ\text{C}$			40	mV
		$R_{LOAD} = 10\text{ k}\Omega\text{ to }V_S / 2$			80	120	mV



**40-V, 12-MHz, Zero-Drift Operational Amplifier**

Symbol	Parameter	Conditions	T <sub>A</sub>	Min	Typ	Max	Unit	
			-40°C to 85°C			170	mV	
			-40°C to 125°C			200	mV	
			R <sub>LOAD</sub> = 2 kΩ to V <sub>S</sub> / 2			370	500	mV
				-40°C to 85°C			700	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			5	25	mV	
			-40°C to 85°C			30	mV	
			-40°C to 125°C			30	mV	
		R <sub>LOAD</sub> = 10 kΩ to V <sub>S</sub> / 2			30	80	mV	
			-40°C to 85°C			95	mV	
			-40°C to 125°C			105	mV	
		R <sub>LOAD</sub> = 2 kΩ to V <sub>S</sub> / 2			140	300	mV	
			-40°C to 85°C			450	mV	
-40°C to 125°C				500	mV			
I <sub>sc</sub>	Output Short-Circuit Current	Source		70	95		mA	
			-40°C to 85°C	55			mA	
I <sub>sc</sub>	Output Short-Circuit Current	Source	-40°C to 125°C	50			mA	
				130	150		mA	
		Sink	-40°C to 85°C	100			mA	
			-40°C to 125°C	85			mA	
<b>AC Specifications</b>								
GBW	Gain-Bandwidth Product				12		MHz	
SR	Slew Rate	G = 1, 10-V step		8	12		V/μs	
			-40°C to 125°C	7			V/μs	
t <sub>OR</sub>	Overload Recovery				500		ns	
t <sub>s</sub>	Settling Time, 0.1%	G = 1, 10-V step			5		μs	
	Settling Time, 0.01%				7		μs	
PM	Phase Margin	R <sub>L</sub> = 10 K, C <sub>L</sub> = 50 pF			60		°	
GM	Gain Margin	R <sub>L</sub> = 10 K, C <sub>L</sub> = 50 pF			10		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 kHz			6		nV/√Hz	
		f = 1 kHz			6		nV/√Hz	
		f = 10 kHz			7		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>			0.0002		%	

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 noted.

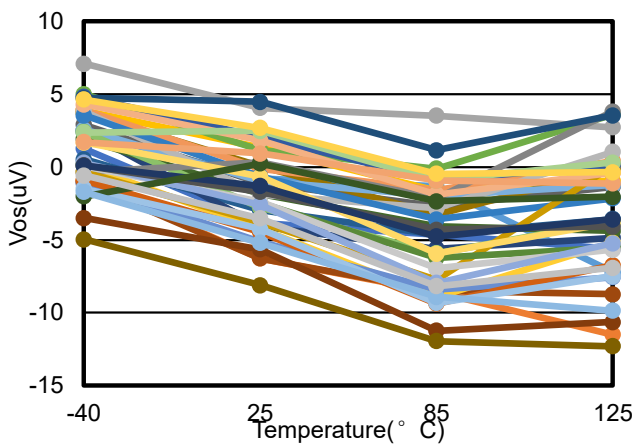


Figure 1.  $V_{OS}$  at 30 V  $V_S$ , 15 V  $V_{CM}$  vs. Temperature, 40 pcs

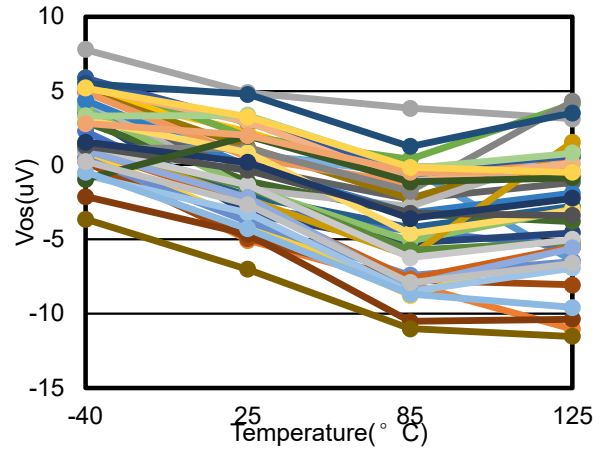


Figure 2.  $V_{OS}$  at 5 V  $V_S$ , 2.5 V  $V_{CM}$  vs. Temperature, 40 pcs

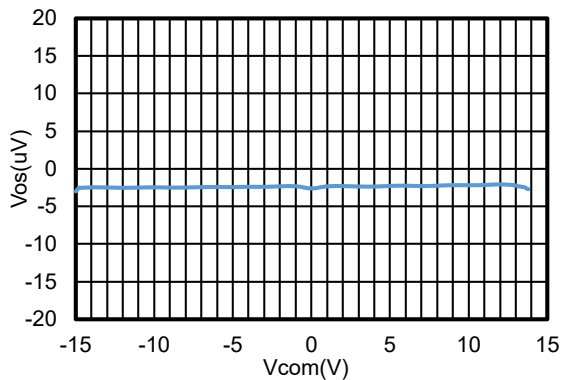


Figure 3. Offset Voltage vs. Common-Mode Voltage

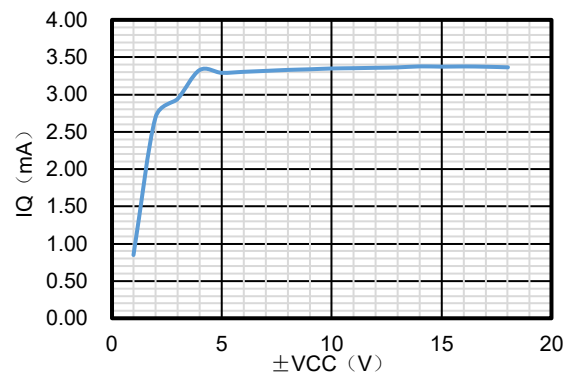


Figure 4.  $I_Q$  vs. Supply Voltage

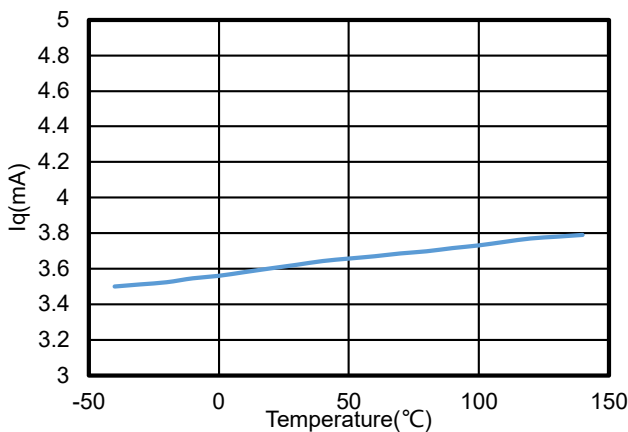


Figure 5.  $I_Q$  vs. Temperature,  $\pm 2.5\text{-V}$  Supply, TPA1882

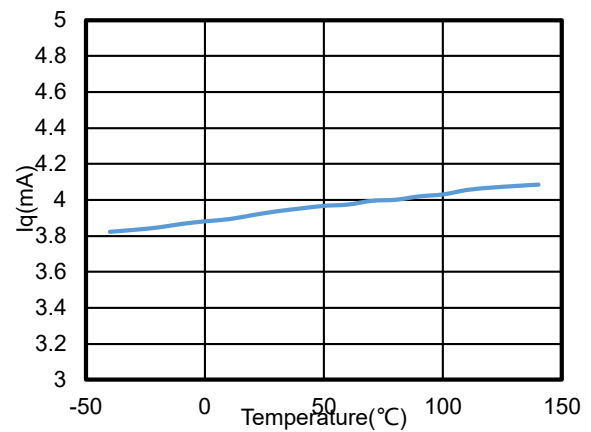


Figure 6.  $I_Q$  vs. Temperature,  $\pm 15\text{-V}$  Supply, TPA1882

40-V, 12-MHz, Zero-Drift Operational Amplifier

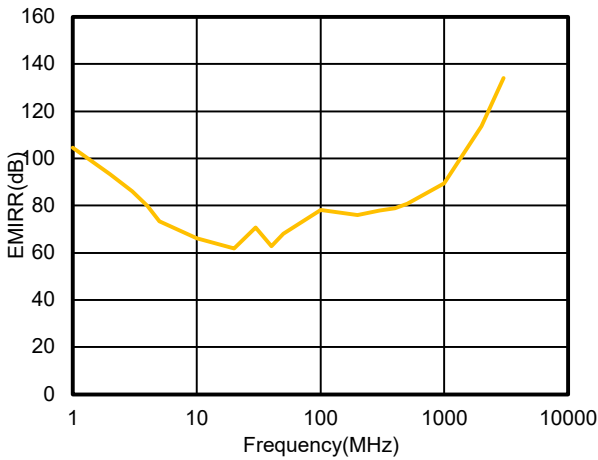


Figure 7. EMIRR vs. Frequency

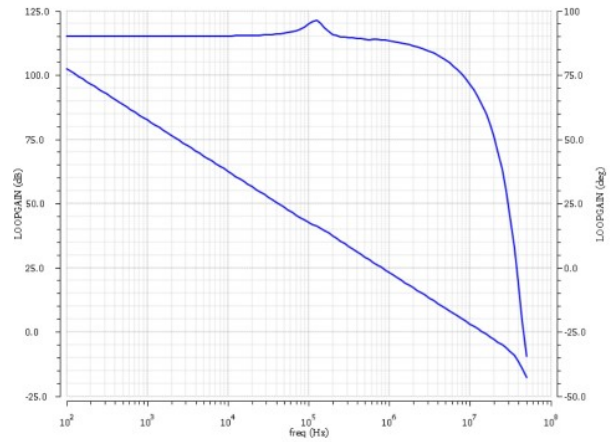


Figure 8. Open-Loop Gain and Phase vs. Frequency,  $R_L = 10\text{ k}\Omega$ ,  $C_L = 50\text{ pF}$

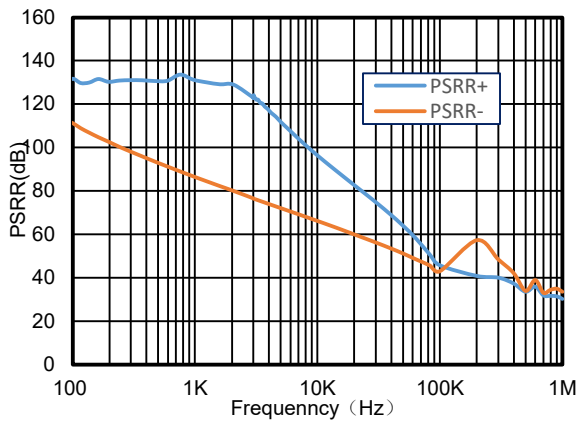


Figure 9. PSRR vs. Frequency

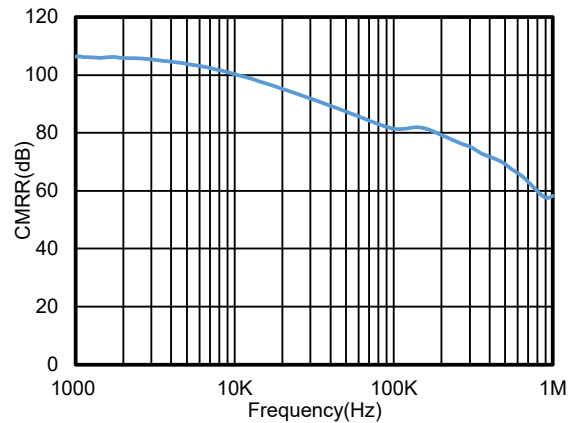
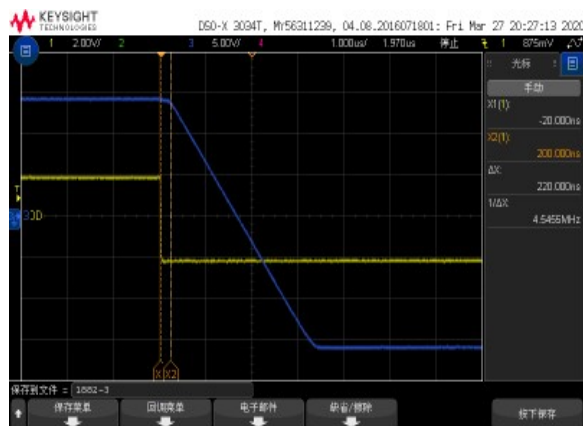


Figure 10. CMRR vs. Frequency



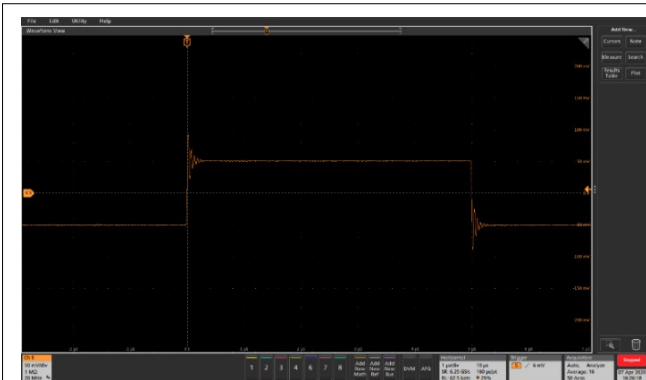
Time: 2 us/div, Measure Time: 220 ns  
 $R_L = 2\text{ k}\Omega$ ,  $C_L = 100\text{ pF}$ ,  $G = 10$

Figure 11. Positive Overload Recovery



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

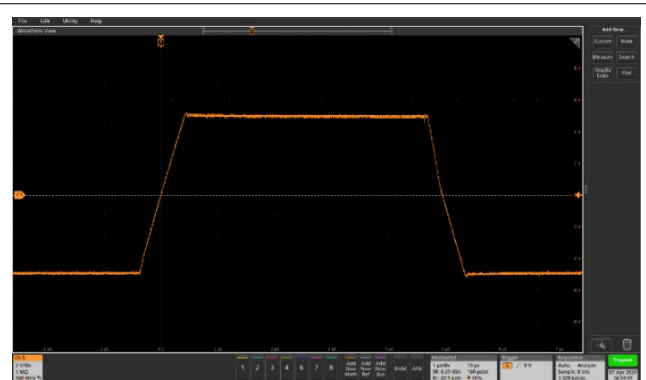
Figure 12. Negative Overload Recovery



Voltage: 50 mV/div, Time: 2 us/div

$R_L = 2\text{ k}\Omega$ ,  $C_L = 100\text{ pF}$ ,  $G = 1$

Figure 13. 100-mV Signal Step Response



Voltage: 2 V/div, Time: 2  $\mu$ s/div

$R_L = 2\text{ k}\Omega$ ,  $C_L = 100\text{ pF}$ ,  $G = 1$

Figure 14. 10-V Signal Step Response

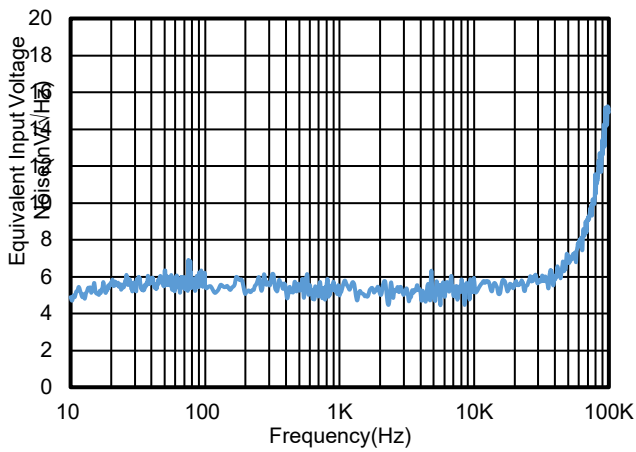


Figure 15. Voltage Noise Spectral Density vs. Frequency

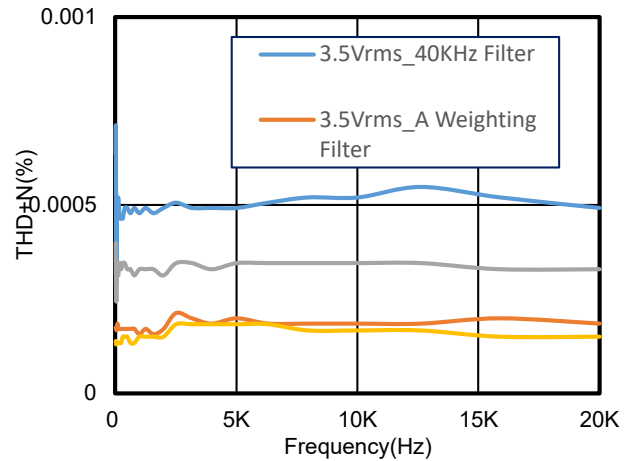


Figure 16. THD+N vs. Frequency

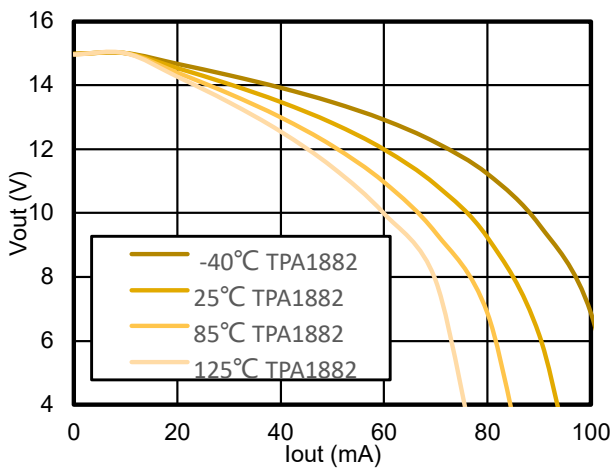


Figure 17.  $V_{OUT}$  vs.  $I_{OUT}$ , Source

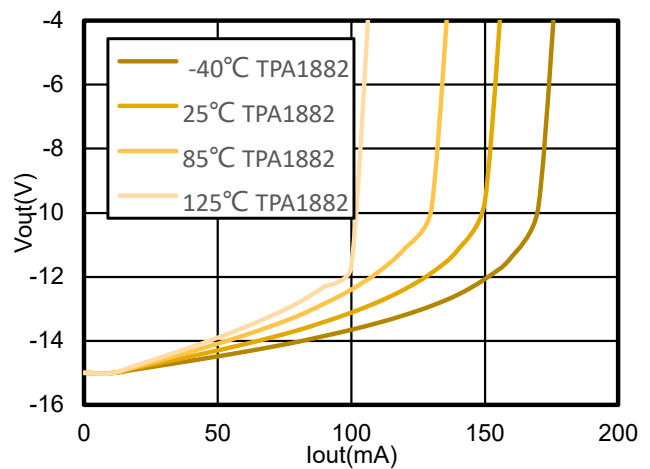


Figure 18.  $V_{OUT}$  vs.  $I_{OUT}$ , Sink

## Detailed Description

### Overview

The TPA188x is a series of op amps that 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 exhibit variance with regard to operating voltage or temperature are presented in [Typical Performance Characteristics](#).

### Functional Block Diagram

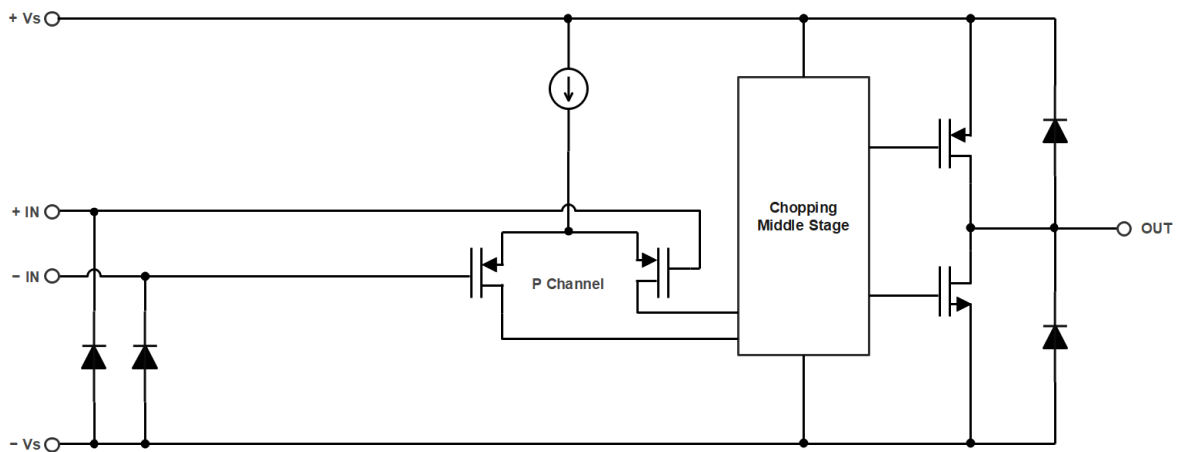


Figure 19. Functional Block Diagram

## Application and Implementation

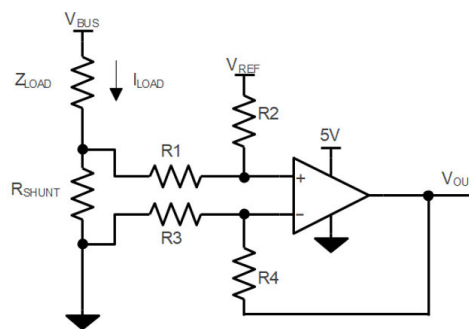
### Note

Information in the following application sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

## Application Information

### Low-Side Current-Sensing Application

Figure 20 shows the TPA188x configured in a low-side current-sensing application. The low-side current-sensing methods include 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 TPA188x.  $V_{REF}$  can be used to add the 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.



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

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

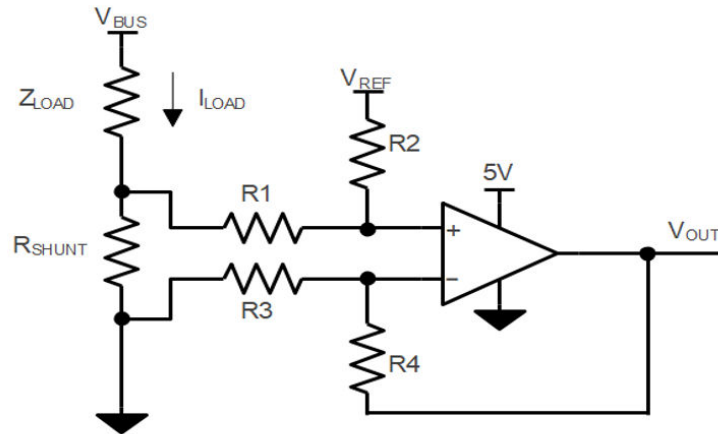
**Figure 20. Dual-Supply Operation Connections**

### Power Supply Recommendations

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

### Typical Application

Figure 21 shows the typical application schematic.

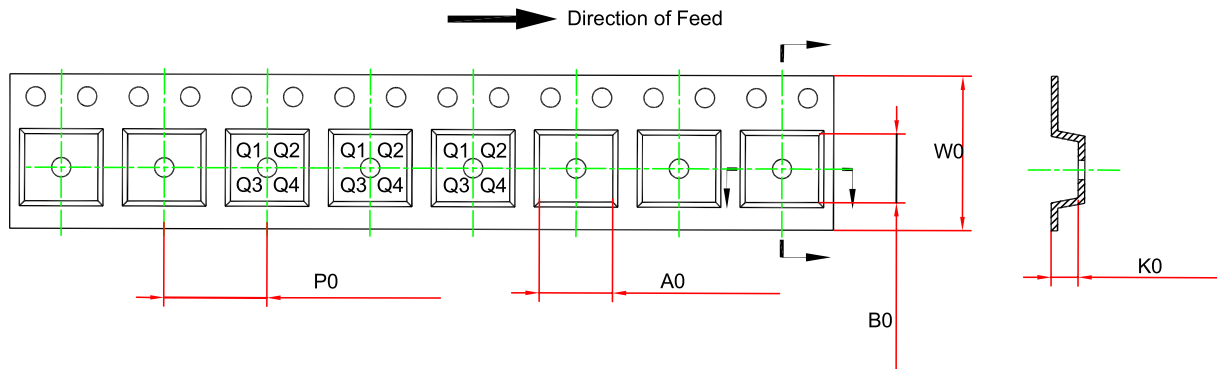
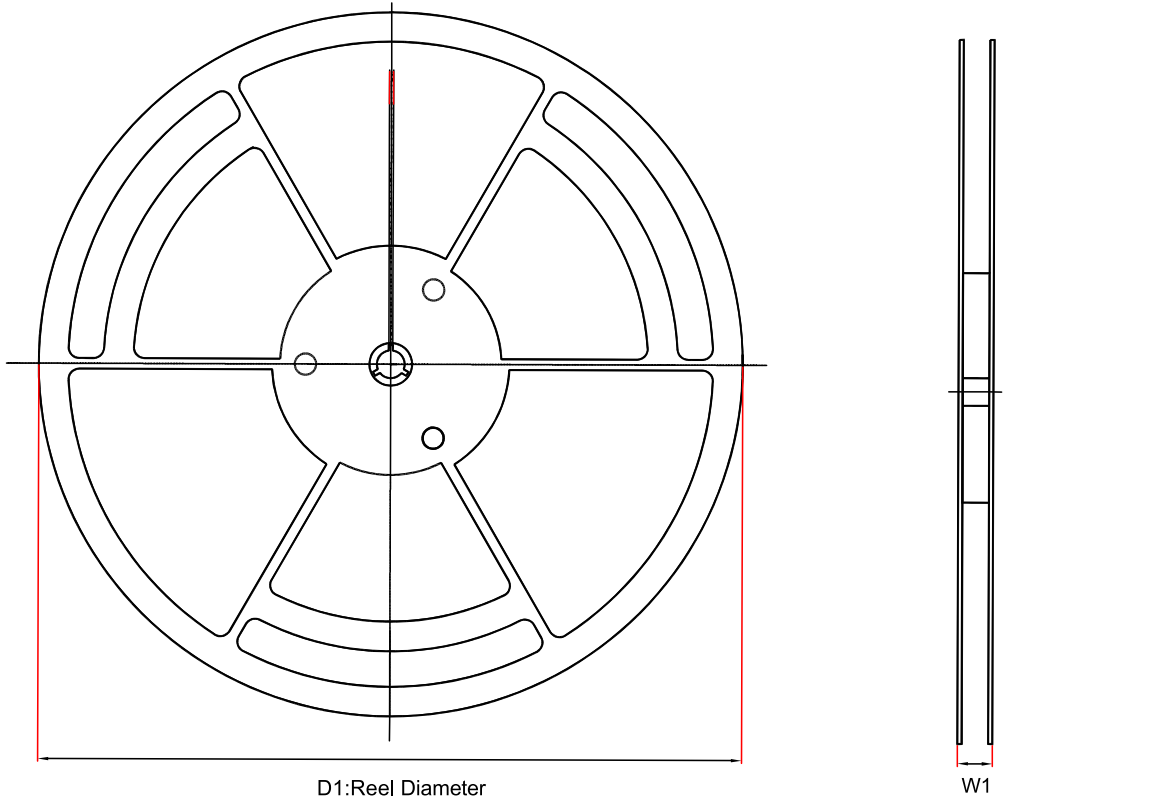


$$V_{OUT} = (I_{LOAD} \times R_{SHUNT}) \times (R2 / R1) + V_{REF}$$

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

Figure 21. Typical Application Circuit

Tape and Reel Information



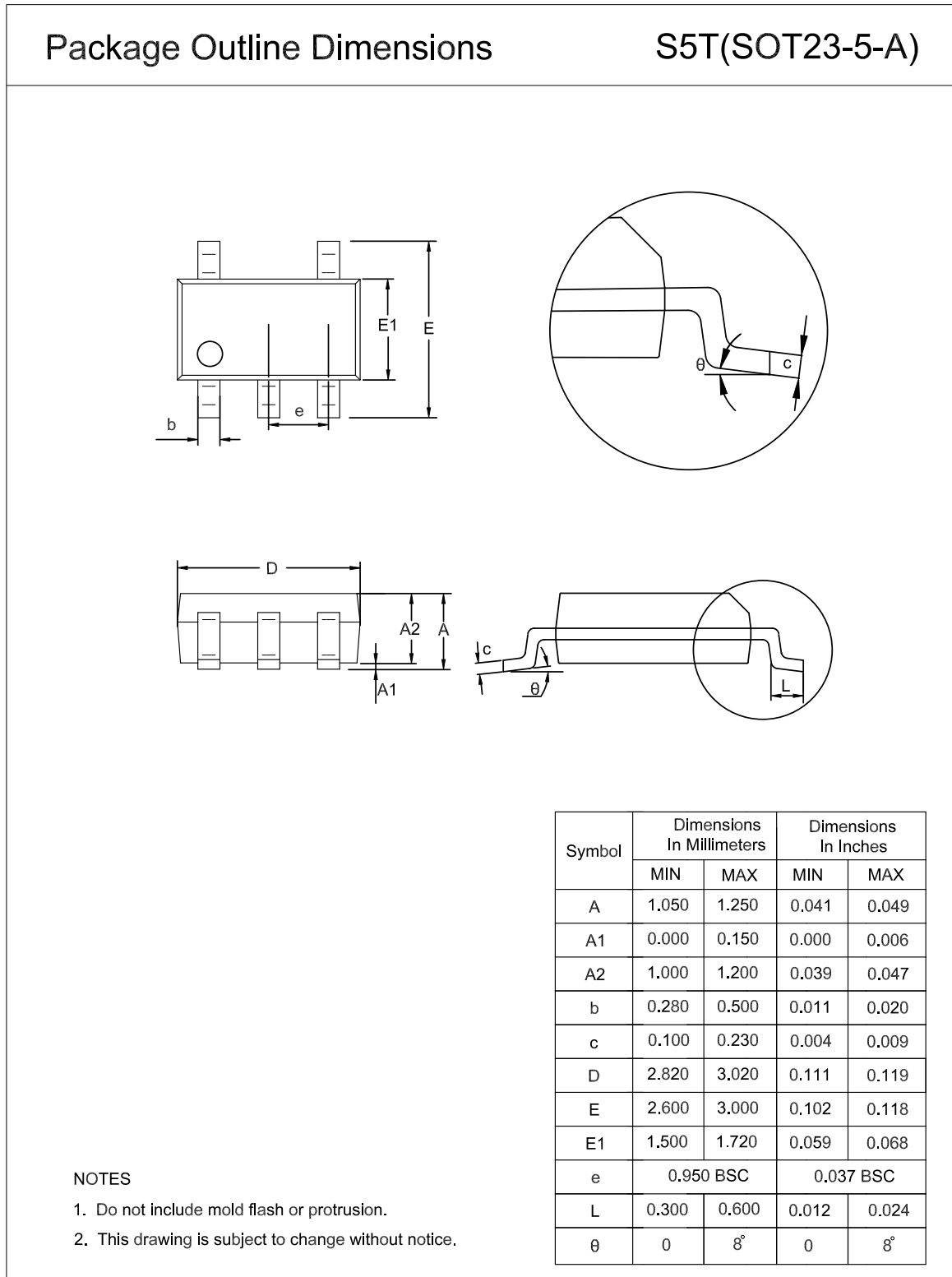
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) <sup>(1)</sup>	B0 (mm) <sup>(1)</sup>	K0 (mm) <sup>(1)</sup>	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA1881-TR	SOT23-5	180.0	13.1	3.2	3.2	1.4	4.0	8.0	Q3
TPA1881-SR	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TPA1882-SR	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TPA1882-VR	MSOP8	330.0	17.6	5.2	3.3	1.5	8.0	12.0	Q1

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



Package Outline Dimensions

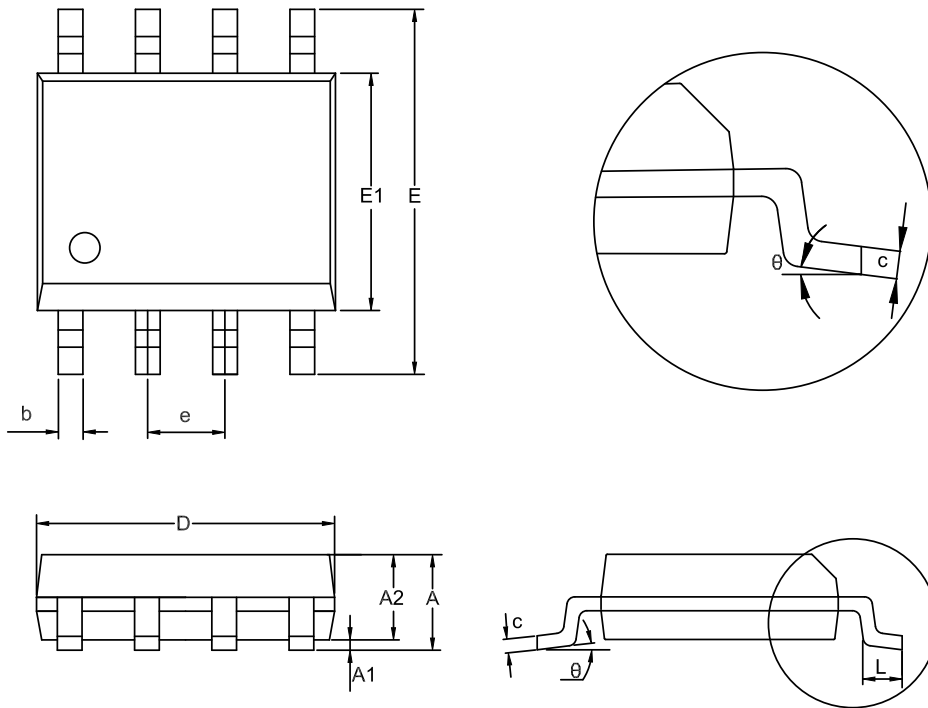
SOT23-5



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
θ	0	8°	0	8°

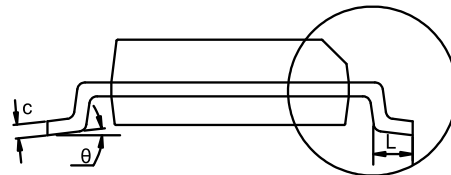
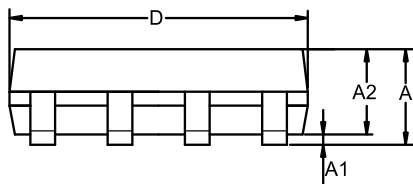
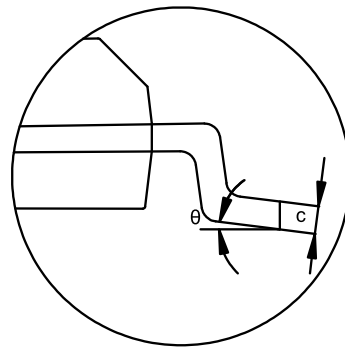
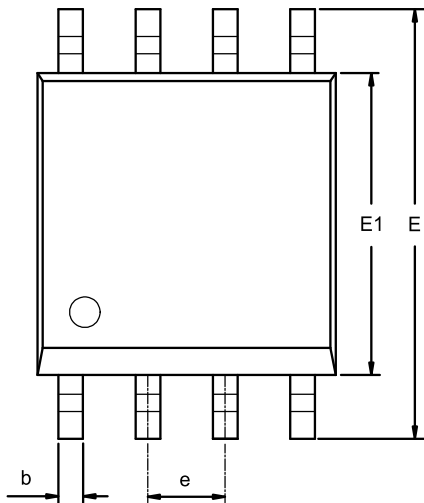
NOTES

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.

## Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPA1881-SR	-40 to 125°C	SOP8	1881	3	Tape and Reel, 4000	Green
TPA1881-TR	-40 to 125°C	SOT23-5	A88	3	Tape and Reel, 3000	Green
TPA1882-SR	-40 to 125°C	SOP8	1882	3	Tape and Reel, 4000	Green
TPA1882-VR	-40 to 125°C	MSOP8	1882	3	Tape and Reel, 3000	Green

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

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