

Features

- Supply Voltage: 4 V to 30 V
- Low Power: 55 μA at 25°C (Typ)
- Low Offset Voltage: $\pm 8 \mu\text{V}$ at 25°C (Max)
- Zero Drift: $\pm 0.01 \mu\text{V}/^\circ\text{C}$
- Rail-to-Rail Output
- Gain-Bandwidth Product: 500 kHz
- Slew Rate: 0.3 V/ μs

Applications

- Battery Test System
- Sensor Interface
- Instrumentation
- Motor Control
- DC Power Supply

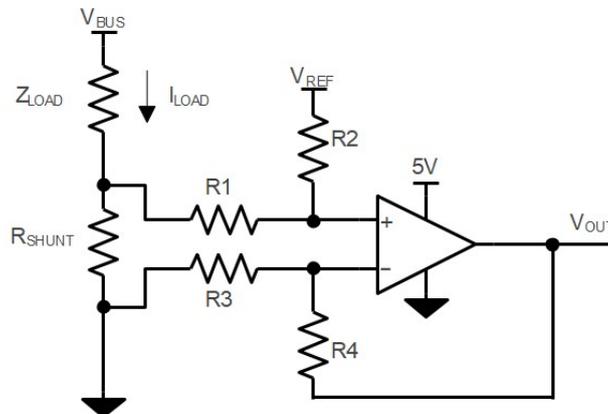
Description

The TPA181x is a series of micro-power and zero-drift amplifiers with a maximum 8- μV low-offset voltage. The TPA181x series features stable frequency response for the high-precision sensing application that also requires low standby power.

The TPA181x series provides rail-to-rail input and output. The series has excellent AC performance with 500-kHz bandwidth and 0.3-V/ μs slew rate while only drawing 55- μA quiescent current per amplifier.

All versions are operated over the industrial temperature range from -40°C to $+125^\circ\text{C}$.

Typical Application Circuit



$$V_{\text{OUT}} = (I_{\text{LOAD}} \times R_{\text{SHUNT}}) \times (R_2 / R_1) + V_{\text{REF}}$$

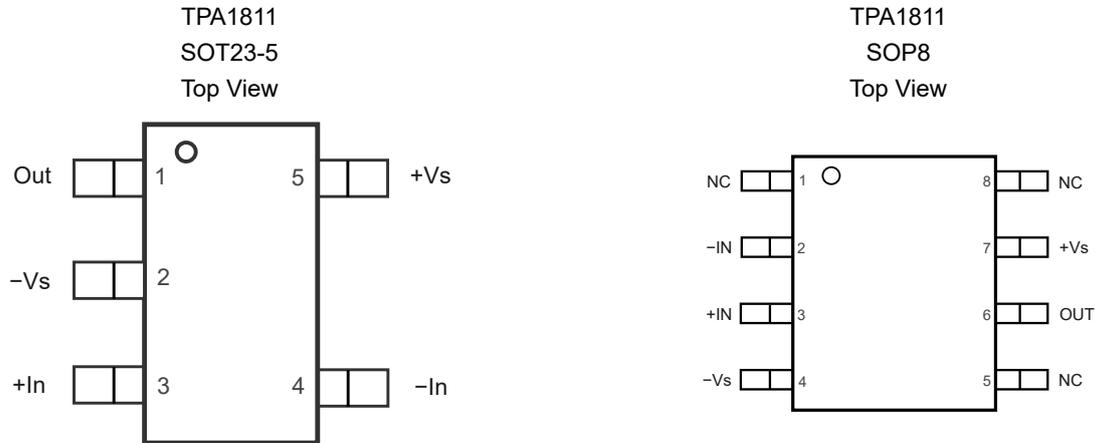
$$\text{When } R_3 = R_1, R_2 = R_4, R_{\text{SHUNT}} \ll R_1$$

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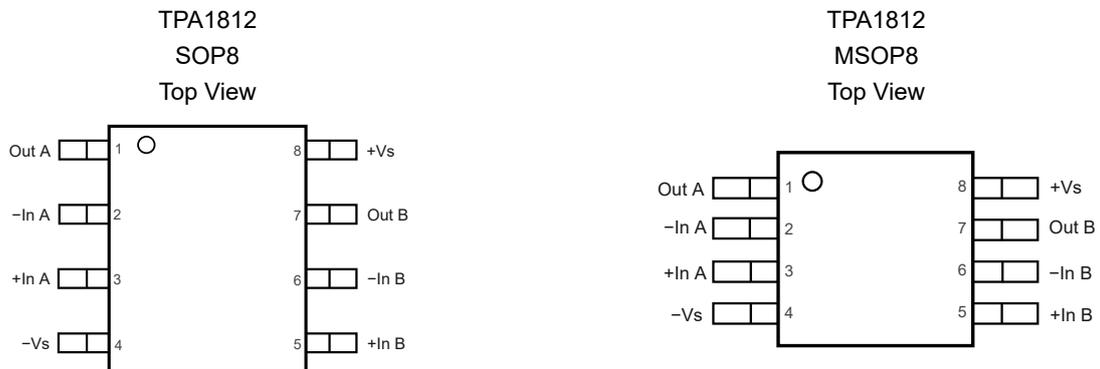
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Revision History

Date	Revision	Notes
2024-07-16	Rev.A.0	Initial version.
2024-12-18	Rev.A.1	The following updates are all about the new datasheet formats or typos, and the actual product remains unchanged. <ul style="list-style-type: none"><li data-bbox="555 584 1018 616">• Updated the Tape and Reel Information.

Pin Configuration and Functions

Table 1. Pin Functions: TPA1811

Pin		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

30-V, 500-kHz, High-Precision, Low-Power, Zero-Drift Op Amps

Table 2. Pin Functions: TPA1812

Pin		Name	I/O	Description
SOP8	MSOP8			
1		Out A	O	Output
2		-In A	I	Inverting input
3		+In A	I	Non-inverting input
4		-Vs		Negative power supply
5		+In B	I	Non-inverting input
6		-In B	I	Inverting input
7		Out B	O	Output
8		+Vs		Positive power supply

Specifications

Absolute Maximum Ratings ⁽¹⁾

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

Parameter		Min	Max	Unit
	Supply Voltage, (+V _S) – (–V _S)		32 V	V
	Input Voltage	(–V _S) – 0.3	32 V	V
	Differential Input Voltage		(+V _S) – (–V _S)	V
	Input Current: +I _N , –I _N ⁽²⁾	–10	10	mA
	Output Voltage	(–V _S) – 0.3	(+V _S) + 0.3	V
	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 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. 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	Value	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.

Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V _S	Supply Voltage	Single Supply	4	30	V
		Dual Supply	±2	±15	V
T _A	Operating Temperature Range	-40		125	°C

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

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Electrical Characteristics

 All test conditions: $V_S = 30\text{ V}$, $T_A = 25^\circ\text{C}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Power Supply						
V_S	Supply Voltage Range	$(+V_S) - (-V_S)$	4		30	V
I_Q	Quiescent Current per Amplifier	$V_S = 30\text{ V}$		55	95	μA
		$V_S = 30\text{ V}$, $T_A = -40^\circ\text{C}$ to 125°C			120	μA
		$V_S = 4\text{ V}$		45	70	μA
		$V_S = 4\text{ V}$, $T_A = -40^\circ\text{C}$ to 125°C			90	μA
PSRR	Power Supply Rejection Ratio	$V_S = 16\text{ V}$ to 30 V	125	150		dB
		$V_S = 16\text{ V}$ to 30 V , $T_A = -40^\circ\text{C}$ to 125°C	115			dB
Input Characteristics						
V_{OS}	Input Offset Voltage	$V_S = 30\text{ V}$, $V_{CM} = 15\text{ V}$	-8	1	8	μV
		$V_S = 30\text{ V}$, $V_{CM} = 15\text{ V}$, $T_A = -40^\circ\text{C}$ to 125°C	-28		28	μV
		$V_S = 30\text{ V}$, $V_{CM} = 15\text{ V}$ ⁽¹⁾	-2	1	2	μV
		$V_S = 30\text{ V}$, $V_{CM} = 15\text{ V}$, $T_A = -40^\circ\text{C}$ to 125°C ⁽¹⁾	-4		4	μV
		$V_S = 4\text{ V}$, $V_{CM} = 2\text{ V}$	-8	1	8	μV
		$V_S = 4\text{ V}$, $V_{CM} = 2\text{ V}$, $T_A = -40^\circ\text{C}$ to 125°C	-28		28	μV
		$V_S = 4\text{ V}$, $V_{CM} = 2\text{ V}$ ⁽¹⁾	-2	1	2	μV
		$V_S = 4\text{ V}$, $V_{CM} = 2\text{ V}$, $T_A = -40^\circ\text{C}$ to 125°C ⁽¹⁾	-4		4	μV
$V_{OS\ TC}$	Input Offset Voltage Drift ⁽²⁾	$T_A = -40^\circ\text{C}$ to 125°C		0.01	0.04	$\mu\text{V}/^\circ\text{C}$
I_B	Input Bias Current	$V_S = 30\text{ V}$, $V_{CM} = 15\text{ V}$ ⁽¹⁾		50	400	pA
		$V_S = 30\text{ V}$, $V_{CM} = 15\text{ V}$, $T_A = -40^\circ\text{C}$ to 125°C ⁽¹⁾			800	pA
		$V_S = 4\text{ V}$, $V_{CM} = 2\text{ V}$		50	400	pA
		$V_S = 4\text{ V}$, $V_{CM} = 2\text{ V}$, $T_A = -40^\circ\text{C}$ to 125°C			800	pA
I_{OS}	Input Offset Current	$V_S = 30\text{ V}$, $V_{CM} = 15\text{ V}$ ⁽¹⁾		50	400	pA
		$V_S = 30\text{ V}$, $V_{CM} = 15\text{ V}$, $T_A = -40^\circ\text{C}$ to 125°C ⁽¹⁾			800	pA
		$V_S = 4\text{ V}$, $V_{CM} = 2\text{ V}$		50	400	pA
		$V_S = 4\text{ V}$, $V_{CM} = 2\text{ V}$, $T_A = -40^\circ\text{C}$ to 125°C			800	pA
R_{IN}	Input Resistance			10^{10}		Ω

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Symbol	Parameter	Conditions	Min	Typ	Max	Unit
C _{IN}	Input Capacitance	Differential Mode		5		pF
		Common Mode		2.5		pF
A _V	Open-Loop Voltage Gain	V _O = 0.5 V to 29.5 V	125	160		dB
		V _O = 0.5 V to 29.5 V, T _A = -40°C to 125°C	120			dB
V _{CMR}	Common-Mode Input Voltage Range	T _A = -40°C to 125°C	-V _S		(+V _S) - 2	V
CMRR	Common-Mode Rejection Ratio	V _{CM} = 0 V to 28 V	125	160		dB
		V _{CM} = 0 V to 28 V, T _A = -40°C to 125°C	120			dB
Output Characteristics						
	Output Voltage Swing from Positive Rail	R _{LOAD} = 100 kΩ to V _S / 2		10	25	mV
		R _{LOAD} = 100 kΩ to V _S / 2, T _A = -40°C to 125°C			40	mV
		R _{LOAD} = 10 kΩ to V _S / 2		100	160	mV
		R _{LOAD} = 10 kΩ to V _S / 2, T _A = -40°C to 125°C			210	mV
	Output Voltage Swing from Negative Rail	R _{LOAD} = 100 kΩ to V _S / 2		8	25	mV
		R _{LOAD} = 100 kΩ to V _S / 2, T _A = -40°C to 125°C			40	mV
		R _{LOAD} = 10 kΩ to V _S / 2		75	160	mV
		R _{LOAD} = 10 kΩ to V _S / 2, T _A = -40°C to 125°C			210	mV
I _{SC}	Output Short-Circuit Current	Sink current		50		mA
		Sink current, T _A = -40°C to 125°C		45		mA
		Source current		50		mA
		Source current, T _A = -40°C to 125°C		45		mA
AC Specifications						
GBW	Gain-Bandwidth Product			500		kHz
SR	Slew Rate	G = 1, 2-V step		0.3		V/μs
t _{OR}	Overload Recovery			3		μs
PM	Phase Margin	R _L = 10 kΩ, C _L = 100 pF		75		°
GM	Gain Margin	R _L = 10 kΩ, C _L = 100 pF		15		dB
Noise Performance						
E _N	Input Voltage Noise	f = 0.1 Hz to 10 Hz		2		μV _{PP}
e _N	Input Voltage Noise Density	f = 1 kHz		50		nV/√Hz

(1) Provided by bench tests and design simulation.

(2) Provided by design simulation.

Typical Performance Characteristics

All test conditions: $V_s = \pm 15\text{ V}$, $R_L = 10\text{ k}\Omega$, unless otherwise noted.

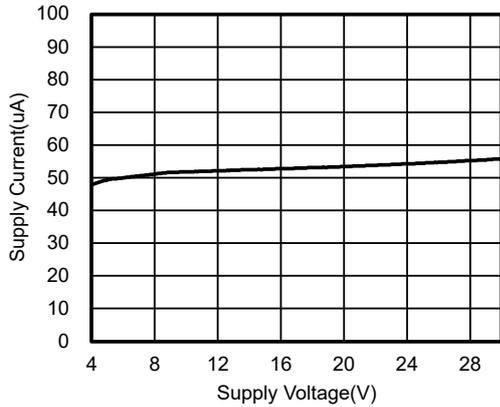


Figure 1. Supply Current vs. Supply Voltage

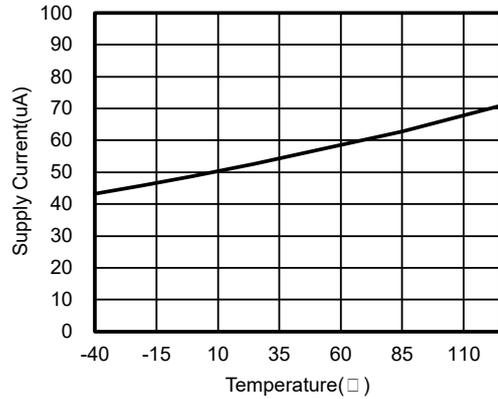


Figure 2. Supply Current vs. Temperature

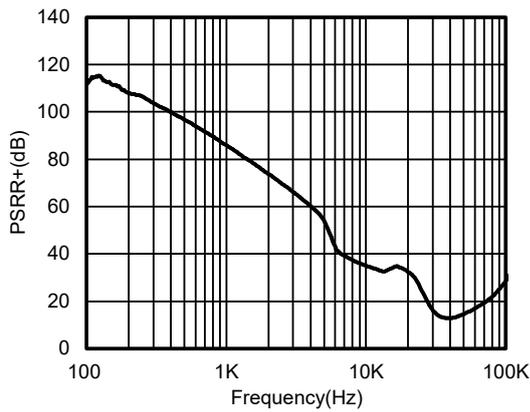


Figure 3. PSRR+ vs. Frequency

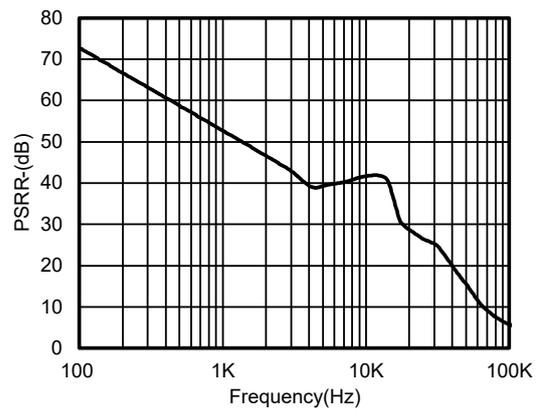


Figure 4. PSRR- vs. Frequency

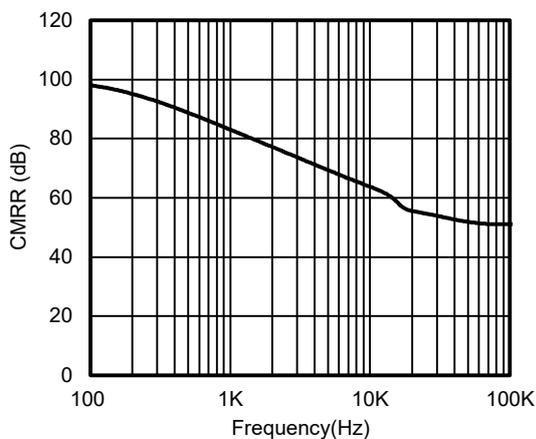


Figure 5. CMRR vs. Frequency

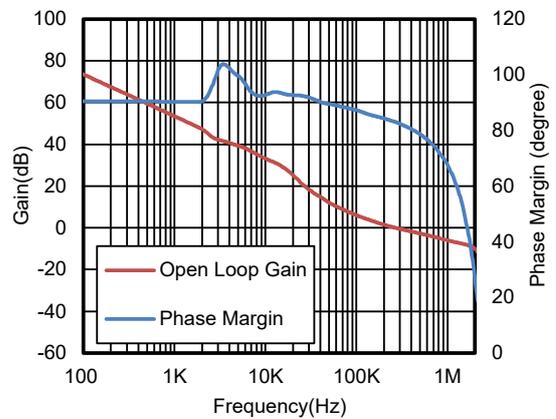


Figure 6. Open-Loop Gain and Phase Margin vs. Frequency, $R_L = 10\text{ k}\Omega$

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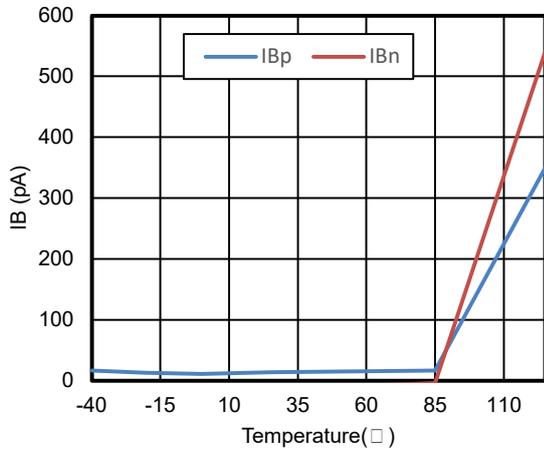


Figure 7. I_B vs. Temperature

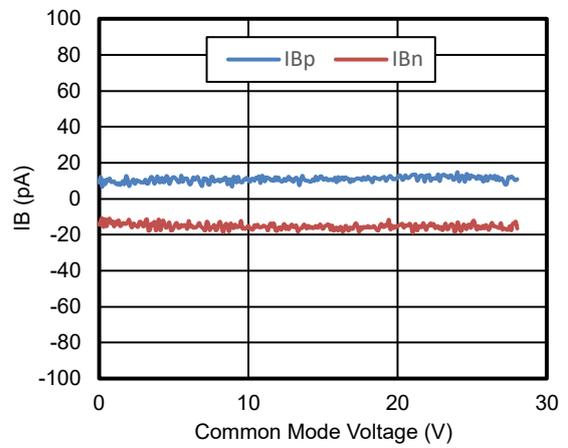


Figure 8. I_B vs. V_{CM}

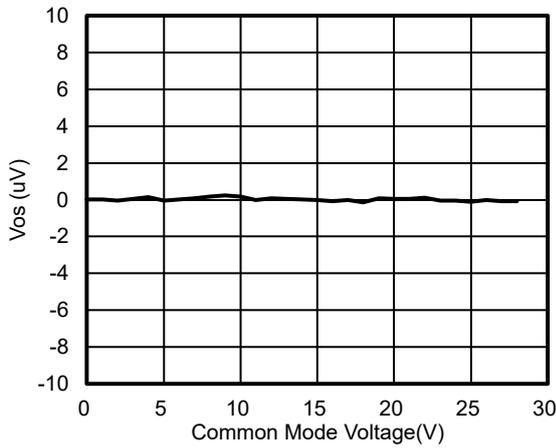


Figure 9. V_{OS} vs. V_{CM} , $V_S = 30\text{ V}$

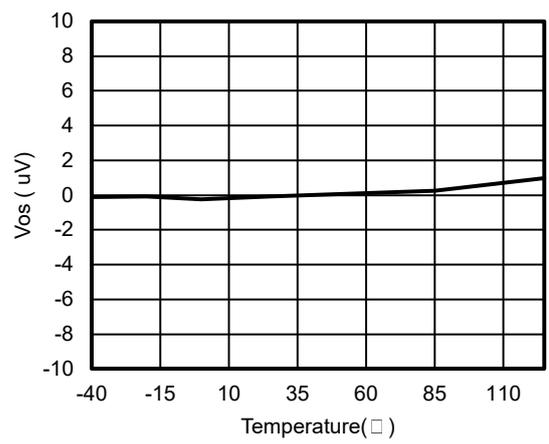


Figure 10. V_{OS} vs. Temperature

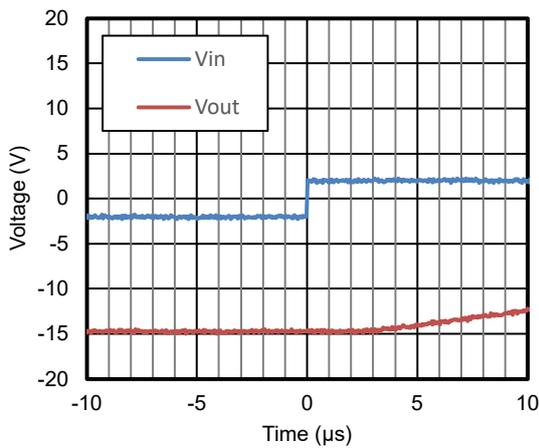


Figure 11. Overload Recovery at Negative Rail

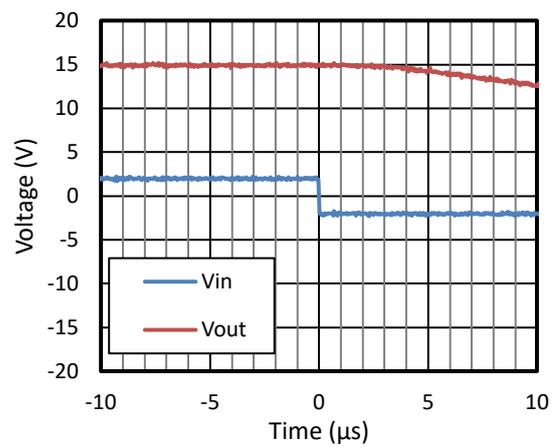


Figure 12. Overload Recovery at Positive Rail

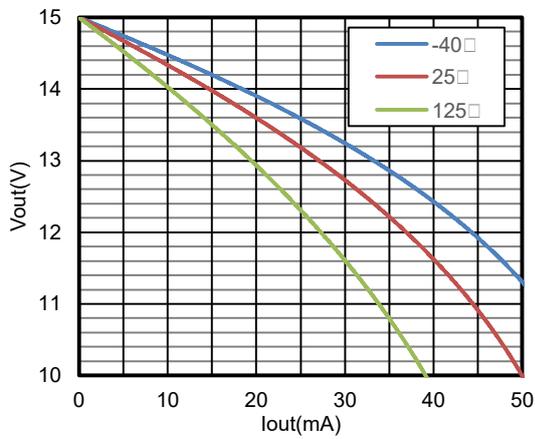
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Figure 13. Output Voltage vs. Output Current, Source,
 $(-V_s) = -15\text{ V}, (+V_s) = 15\text{ V}$

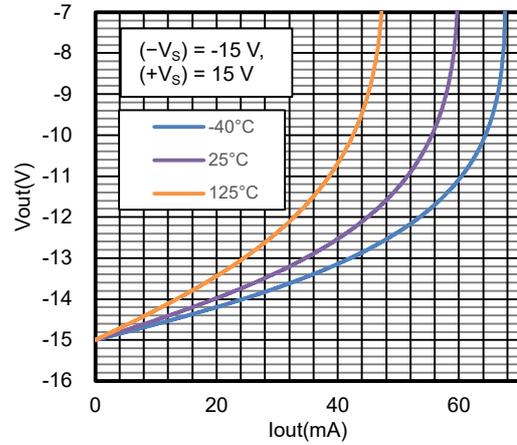


Figure 14. Output Voltage vs. Output Current, Sink, $(-V_s)$
 $= -15\text{ V}, (+V_s) = 15\text{ V}$

Detailed Description

Overview

The TPA181x is a series of zero-drift amplifiers that operate on a single-supply voltage (4 V to 30 V), or a split-supply voltage. With the precision auto-calibration technique, these amplifiers achieve low input offset voltage and input offset voltage drift which can achieve outstanding input and output dynamic linearity. The strengths of the TPA181x also include 500-kHz bandwidth, no $1/f$ noise, and only 55- μ A quiescent current, making the TPA181x suitable for many precision, low-power, and temperature-sensitive applications. Parameters that exhibit variance with regard to operating voltage or temperature are presented in [Typical Performance Characteristics](#).

Functional Block Diagram

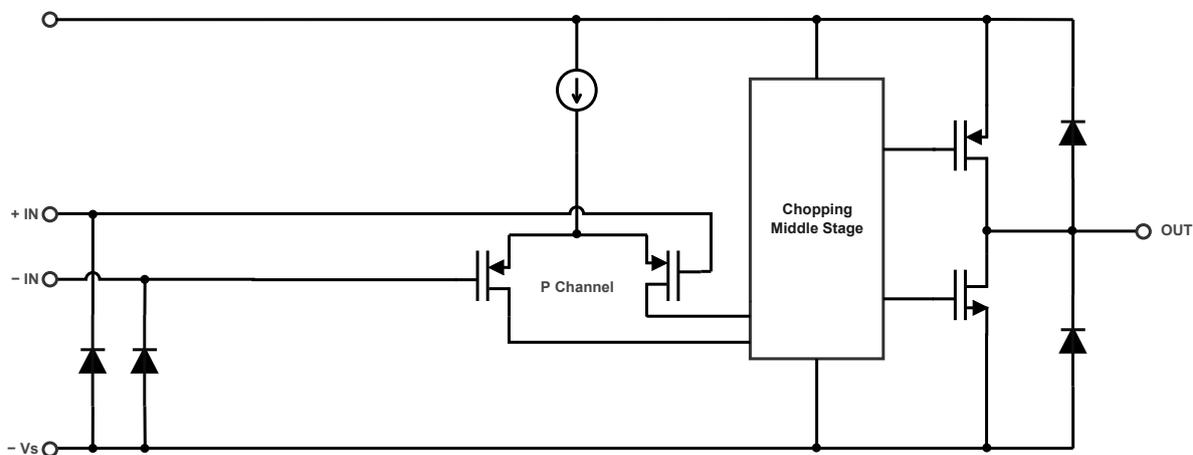


Figure 15. Functional Block Diagram

Feature Description

Operating Voltage

The devices are designed for single-supply operation from 4 V to 30 V, or dual-supply operation from ± 2 V to ± 15 V.

The recommended operating voltage conditions are as follows:

Power supply voltage ($+V_S$) - ($-V_S$): 4 V to 30 V. The power supply voltage can support the following three scenarios:

- Single supply;
- Dual supplies with equal voltage values;
- Various voltage configurations, as long as the voltage range of ($+V_S$) - ($-V_S$) is within 4 V to 30 V.

For example, if operating with a single supply, ($-V_S$) = 0 V, then ($+V_S$) can support 4 V to 30 V. If using dual supplies with equal absolute values, the minimum voltage is ± 2 V, and the maximum voltage is ± 15 V. It can even support other voltage configurations, such as ($-V_S$) = 100 V, ($+V_S$) = 130 V, or ($-V_S$) = -6 V, ($+V_S$) = 24 V, and so on.

Ultra-Low Offset Voltage and Offset Voltage Drift in Operating Temperature Range

These devices provide 4- μ V offset voltage within the temperature range from -40°C to 125°C , which is achieved through the chopper stabilized technology. This unique topology allows these devices to maintain their low-offset voltage over a wide temperature range and their operating lifetime.

Low 1/f Noise

Flicker noise, as known as 1/f noise, is inherent in semiconductor devices and increases as the frequency decreases. The flicker noise provides higher degrees of error for low-frequency applications. The devices use the chopper stabilized technology to reduce flicker noise. This reduction in 1/f noise allows the devices to have lower noise at DC and low-frequency range compared to the standard amplifier.

Residual Voltage Ripple

The chopping technique can be used in the amplifier design due to the internal notch filter. Although the chopping-related voltage ripple is suppressed, a higher noise spectrum exists at the chopping frequency and its harmonics due to residual ripple.

The devices set the chopping frequency to around 100 kHz. If the frequency of input signal is close to the chopping frequency, the signal may be interfered by the residue ripple. To suppress the noise at the chopping frequency, it is recommended that a post filter be placed at the output of the amplifier.

Rail-to-Rail Output

The devices deliver rail-to-rail output swing capability with a class-AB output stage. Different load conditions change the ability of the amplifier to swing close to the rails.

Application and Implementation

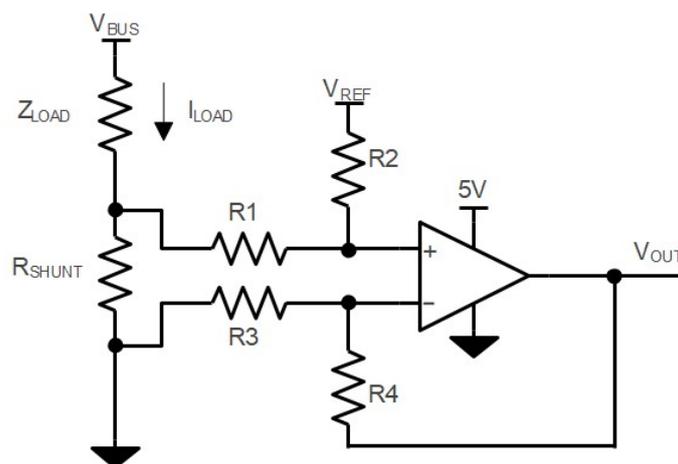
Note

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 16 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. 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.



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

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

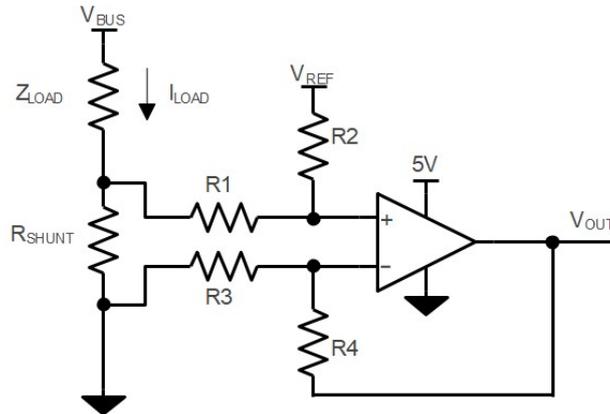
Figure 16. Low-Side Current-Sensing Application

Power Supply Recommendations

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

Typical Application

Figure 17 shows the typical application schematic.

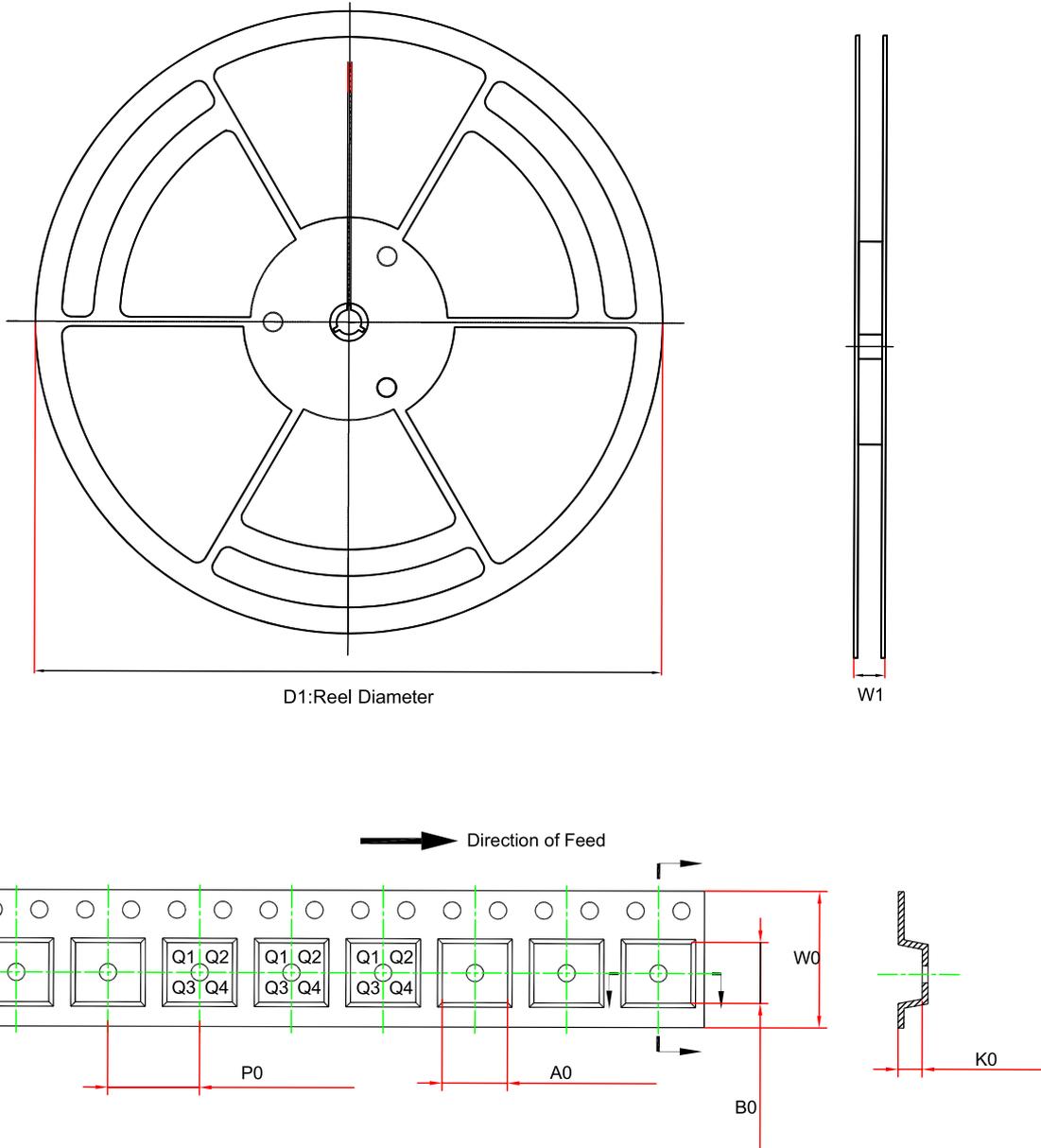


$$V_{OUT} = (I_{LOAD} \times R_{SHUNT}) \times (R_2 / R_1) + V_{REF}$$

When $R_3 = R_1$, $R_2 = R_4$, $R_{SHUNT} \ll R_1$

Figure 17. Typical Application Circuit

Tape and Reel Information

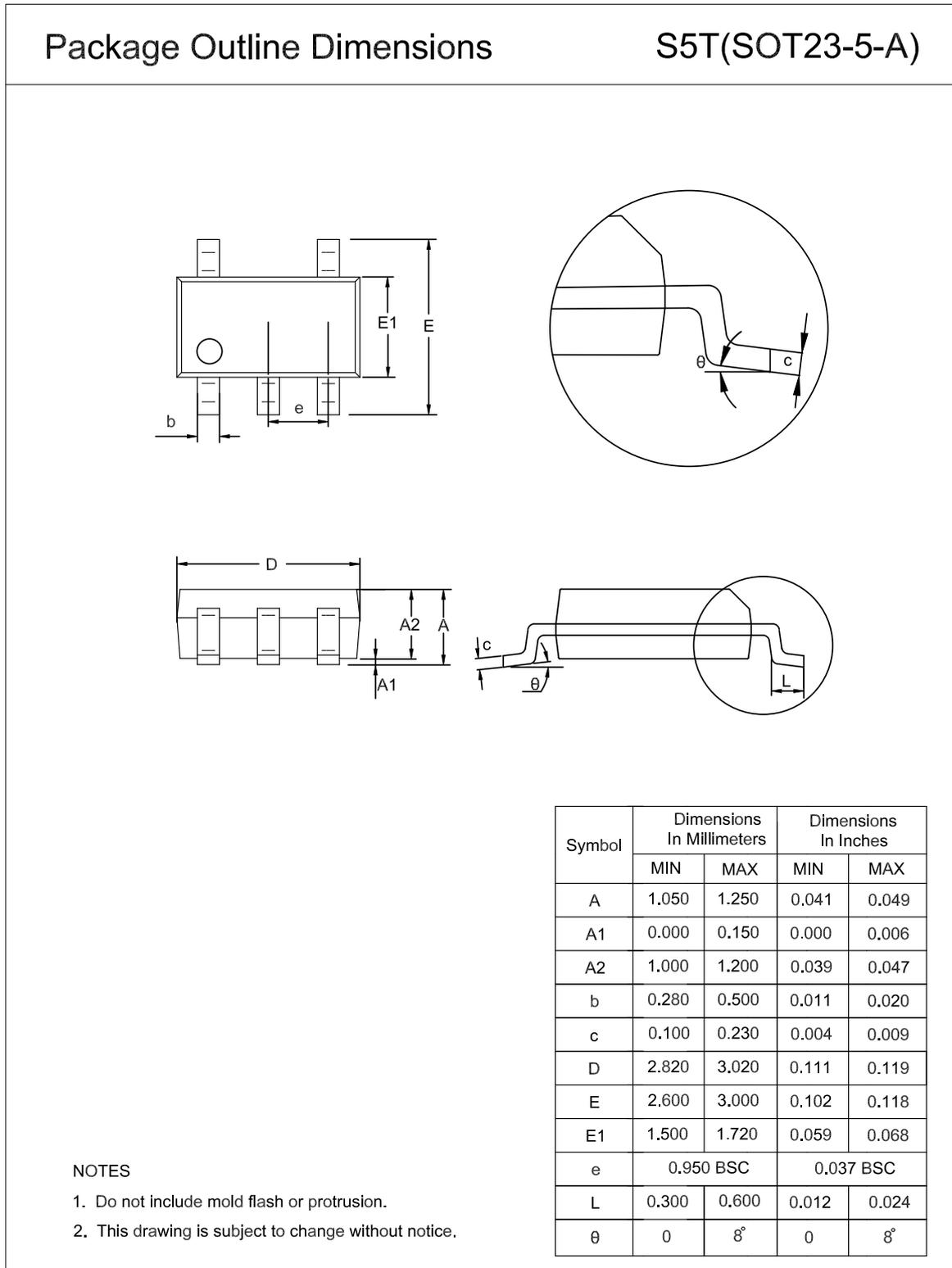


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) ⁽¹⁾	B0 (mm) ⁽¹⁾	K0 (mm) ⁽¹⁾	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA1811-S5TR	SOT23-5	180	12	3.3	3.25	1.4	4	8	Q3
TPA1811-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
TPA1812-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
TPA1812-VS1R	MSOP8	330	17.6	5.3	3.4	1.3	8	12	Q1

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

Package Outline Dimensions

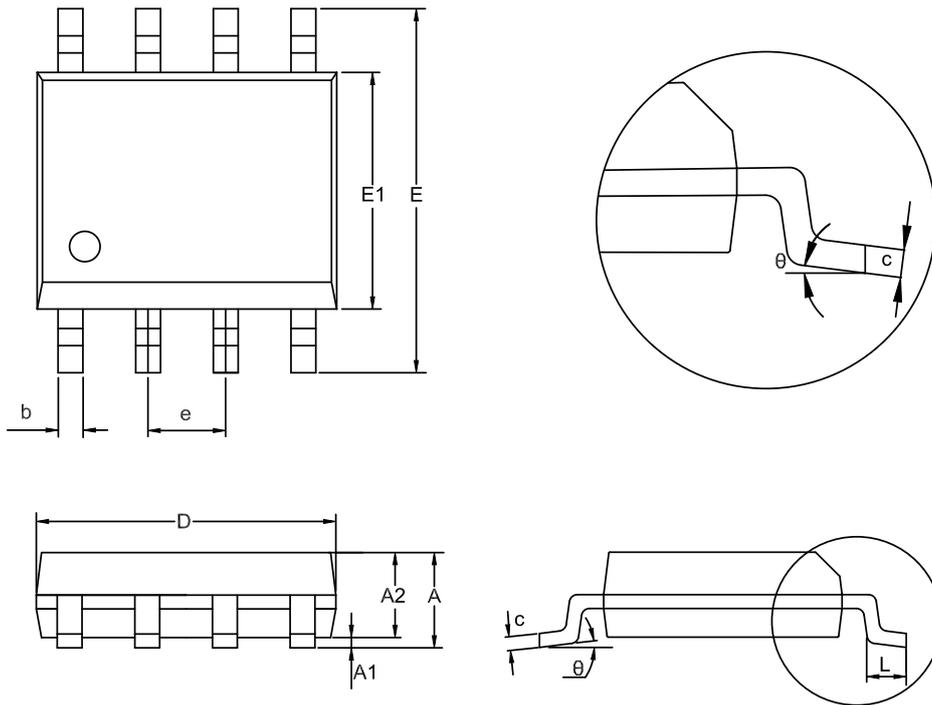
SOT23-5



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°

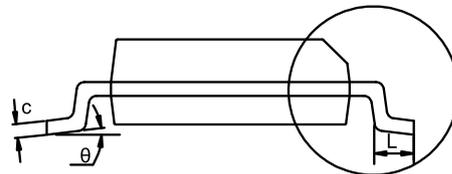
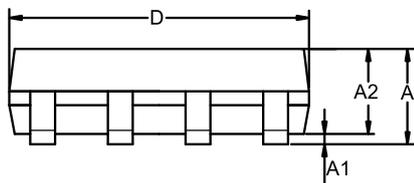
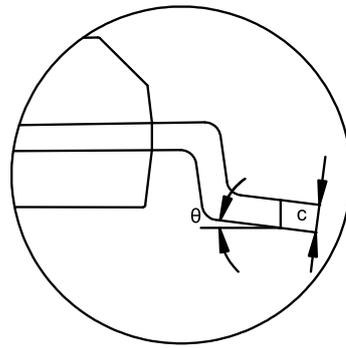
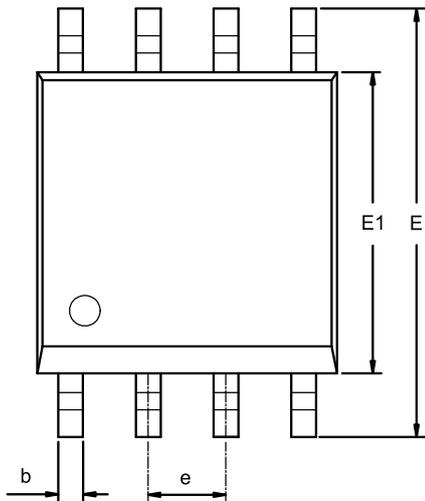
NOTES

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
TPA1811-S5TR	-40 to 125°C	SOT23-5	181	3	Tape and Reel, 3000	Green
TPA1811-SO1R	-40 to 125°C	SOP8	A1811	3	Tape and Reel, 4000	Green
TPA1812-SO1R	-40 to 125°C	SOP8	A1812	3	Tape and Reel, 4000	Green
TPA1812-VS1R	-40 to 125°C	MSOP8	A1812	3	Tape and Reel, 3000	Green

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

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