30-V, 1.1-MHz, High-Precision, Low-Power, Zero-Drift Op Amps

Features

- Supply Voltage: 4 V to 30 V
- Low Power: Typical 140 μA at 25°C
- Low Offset Voltage: ±7 μV Maximum at 25°C
- Zero Drift: ±0.01 μV/°C
- Rail-to-Rail Output
- Gain Bandwidth Product: 1.1 MHz
- Slew Rate: 0.7 V/μs

Applications

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

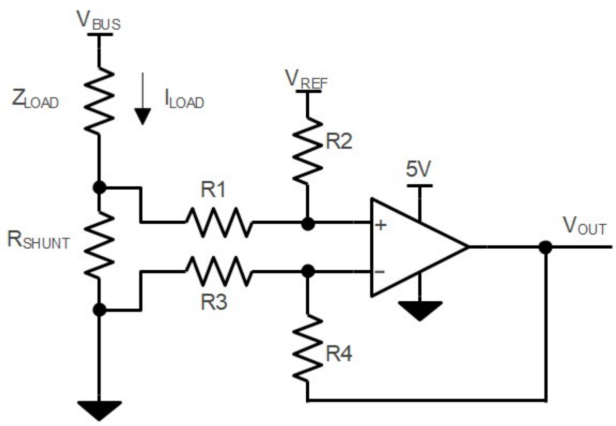
Description

The TPA183x is the mirco-power, zero-drift amplifier with maximum 18-μV low-offset voltage and stable frequency response for the high-precision sensing applicaiton that also requires low standby power.

The TPA183x series of devices provide rail-to-rail input and output. These devices have excellent AC performance with 1.1-MHz bandwidth, 0.7-V/us slew rate while only drawing 140-uA quiescent current per amplifier.

All versions can be operated over the industrial temperature range of −40°C to +125°C.

Typical Application Circuit



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

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

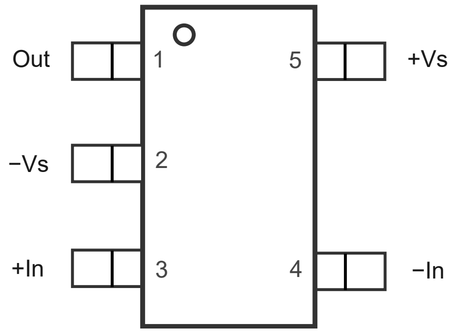
Table of Contents

Revision History

Date	Revision	Notes
2023-09-16	Rev.A.0	Initial version.
2024-04-16	Rev.A.1	Added more description about the operating voltage in Feature Description. Added label for TPA1831U-S5TR and TPA1832-VS1R. Modified the typical value of offset voltage drift from 0.037 to 0.01. Added 0.04 as the maximum value of offset voltage drift.

Pin Configuration and Functions

TPA1831
SOT23-5 Package
Top View



TPA1831
SOP8 Package
Top View

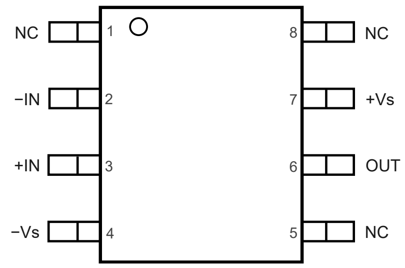
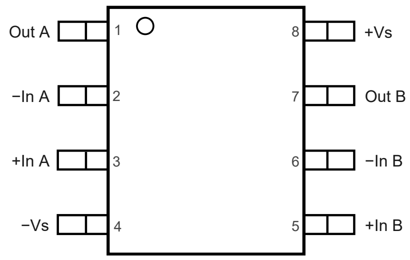


Table 1. Pin Functions: TPA1831

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

TPA1832
SOP8 Package
Top View



TPA1832
MSOP8 Package
Top View

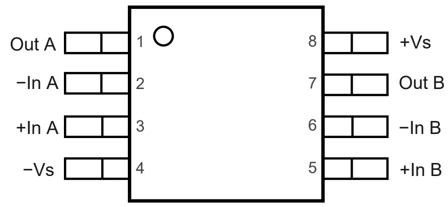
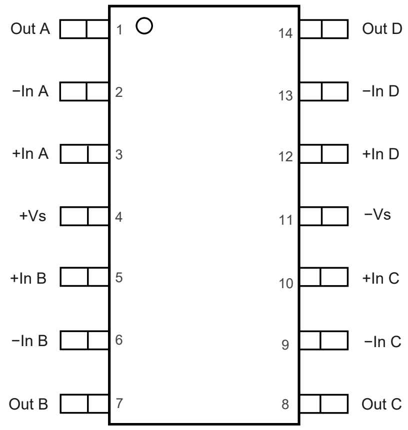


Table 2. Pin Functions: TPA1832

Pin		Name	I/O	Description
SOP8	MSOP8			
1		Out A	Output	Output
2		−In A	Input	Inverting input
3		+In A	Input	Noninverting input
4		$-V_S$		Negative power supply
5		+In B	Input	Noninverting input
6		−In B	Input	Inverting input
7		Out B	Output	Output
8		$+V_S$		Positive power supply

TPA1834
SOP14 Package
Top View



TPA1834
TSSOP14 Package
Top View

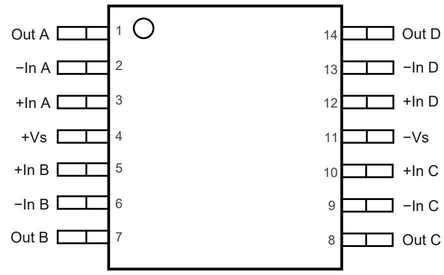


Table 3. Pin Functions: TPA1834

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

Specifications

Absolute Maximum Ratings [1]

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	$(−V_S) − (+V_S)$	$(+V_S) − (−V_S)$	V
Input Current: +IN, –IN [2]	−10	10	mA
Output Voltage	$(−V_S) − 0.3$	$(+V_S) + 0.3$	V
Output Short-Circuit Duration [3]		Infinite	
Maximum Operating Junction Temperature		150	°C
Operating Temperature Range	−40	125	°C
Storage Temperature Range	−65	150	°C
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 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]	1.5	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, (+V_S) – (−V_S)	4 or ±2		30 or ±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
SOP14	120	36	°C/W
TSSOP14	180	35	°C/W

Electrical Characteristics

Test condition is at V_S = 30 V, T_A = 25°C, R_L = 10 kΩ, C_L = 100 pF, unless otherwise noted

Parameter		Conditions	Min	Typ	Max	Unit
Power Supply						
V_S	Supply Voltage Range		4		30	V
I_Q	Quiescent Current per Amplifier	V_S = 30 V		140	200	μA
		V_S = 30 V, T_A = −40°C to 125°C			260	μA
		V_S = 4 V		120	170	μA
		V_S = 4 V, T_A = −40°C to 125°C			220	μA
PSRR	Power Supply Rejection Ratio	V_S = 4 V to 30 V	120	150		dB
		V_S = 4 V to 30 V , T_A = −40°C to 125°C	110			dB
Input Characteristics						
V_{OS}	Input Offset Voltage	V_S = 30 V, V_{CM} = 15 V	-7	1	7	μV
		V_S = 30 V, V_{CM} = 15 V, T_A = −40°C to 125°C	-28		28	μV
		V_S = 30 V, V_{CM} = 15 V (1)	-2	1	2	μV
		V_S = 30 V, , V_{CM} = 15 V, T_A = −40°C to 125°C (1)	-4		4	μV
		V_S = 4 V, V_{CM} = 2 V	-7	1	7	μV
		V_S = 4 V, V_{CM} = 2 V, T_A = −40°C to 125°C	-28		28	μV
		V_S = 4 V, V_{CM} = 2 V (1)	-2	1	2	μV
		V_S = 4 V, V_{CM} = 2 V, T_A = −40°C to 125°C (1)	-4		4	μV
V_{OS} TC	Input Offset Voltage Drift(2)	T_A = −40°C to 125°C		0.01	0.04	μV/°C
I_B	Input Bias Current	V_S = 4 V, V_{CM} = 2 V		20	1000	pA
		V_S = 4 V, V_{CM} = 2 V, T_A = −40°C to 125°C			5000	pA
		V_S = 30 V, V_{CM} = 15 V (1)		50	1000	pA
		V_S = 30 V, , V_{CM} = 15 V, T_A = −40°C to 125°C (1)			5000	pA
I_{OS}	Input Offset Current	V_S = 4 V, V_{CM} = 2 V		20	1000	pA
		V_S = 4 V, V_{CM} = 2 V, T_A = −40°C to 125°C			5000	pA
		V_S = 30 V, V_{CM} = 15 V (1)		50	1000	pA
		V_S = 30 V, , V_{CM} = 15 V, T_A = −40°C to 125°C (1)			5000	pA
R_{IN}	Input Resistance			10^{10}		Ω

Parameter		Conditions	Min	Typ	Max	Unit
C_{IN}	Input Capacitance	Differential Mode		5		pF
		Common Mode		2.5		pF
Av	Open−loop Voltage Gain	V_O = 0.5 V to 29.5 V	125	150		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	120	160		dB
		V_{CM} = 0 V to 28 V, T = −40°C to 125°C	110			dB
Output Characteristics						
	Output Voltage Swing from Positive Rail	R_{LOAD} = 100 kΩ to V_S/2		15	21	mV
		R_{LOAD} = 100 kΩ to V_S/2, T_A = −40°C to 125°C			100	mV
		R_{LOAD} = 10 kΩ to V_S/2		110	151	mV
		R_{LOAD} = 10 kΩ to V_S/2, T_A = −40°C to 125°C			200	mV
	Output Voltage Swing from Negative Rail	R_{LOAD} = 100 kΩ to V_S/2		9.5	21	mV
		R_{LOAD} = 100 kΩ to V_S/2, T_A = −40°C to 125°C			100	mV
		R_{LOAD} = 10 kΩ to V_S/2		90	151	mV
		R_{LOAD} = 10 kΩ to V_S/2, T_A = −40°C to 125°C			200	mV
I_{SC}	Output Short−Circuit Current	Sink current	45	62		mA
		Sink current, T_A= −40°C to 125°C	35			mA
		Source current	45	62		mA
		Source current, T_A= −40°C to 125°C	35			mA
AC Specifications						
GBW	Gain−Bandwidth Product			1.1		MHz
SR	Slew Rate	G = 1, 2 V step		0.7		V/μs
t_{OR}	Overload Recovery			3		μs
PM	Phase Margin	R_L = 10 kΩ, C_L = 100 pF		60		°
GM	Gain Margin	R_L = 10 kΩ, C_L = 100 pF		7.4		dB
Noise Performance						
E_N	Input Voltage Noise	f = 0.1 Hz to 10 Hz		1		$μV_{PP}$
e_N	Input Voltage Noise Density	f = 1kHz		32		nV/√Hz
THD+N	Total Harmonic Distortion and Noise	f = 1 kHz, G =1, No road, V_{OUT} = 2 V_{pp}		110		dB

(1) Provided by bench test and design simulation.
(2) Provided by design simulation.

Typical Performance Characteristics

All test condition: V_S = ±15 V, R_L = 10 kΩ, unless otherwise noted.

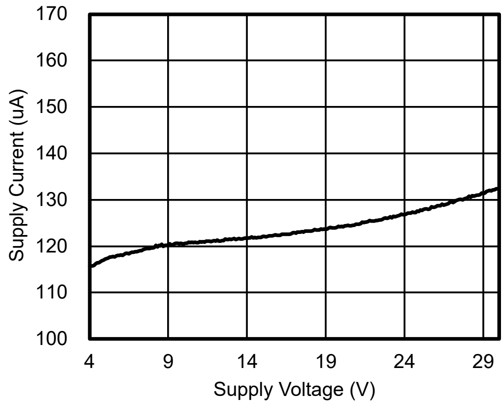


Figure 1. Supply Current vs Supply Voltage

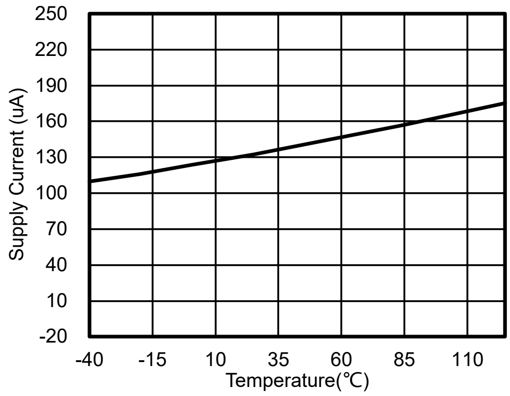


Figure 2. Supply Current vs Temperature

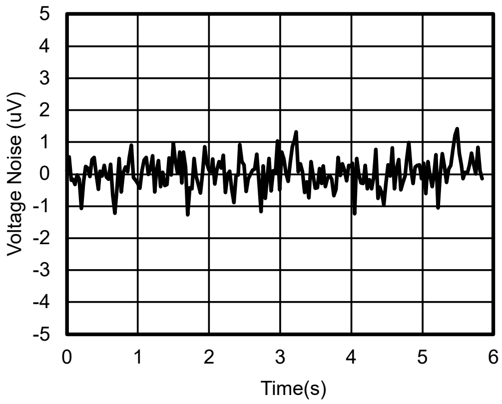


Figure 3. 0.1 to 10 Hz Voltage Noise

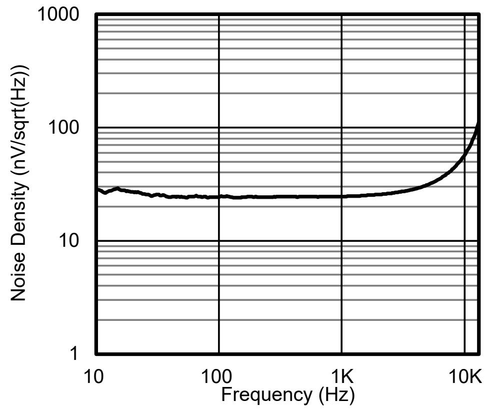


Figure 4. Voltage Noise Spectral Density vs Frequency

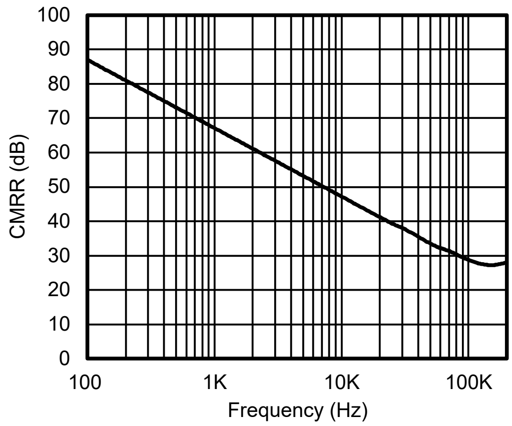


Figure 5. CMRR vs Frequency

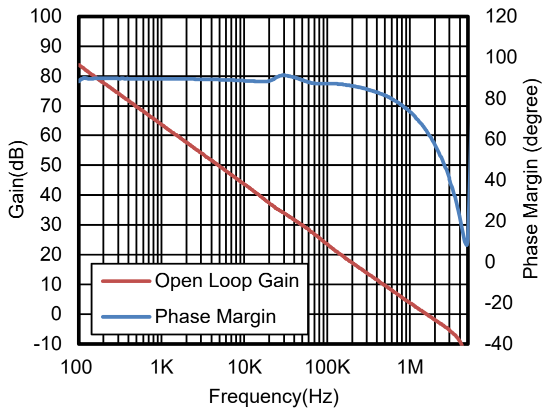


Figure 6. Open Loop Gain and Phase Margin vs Frequency, RL = 10 kΩ

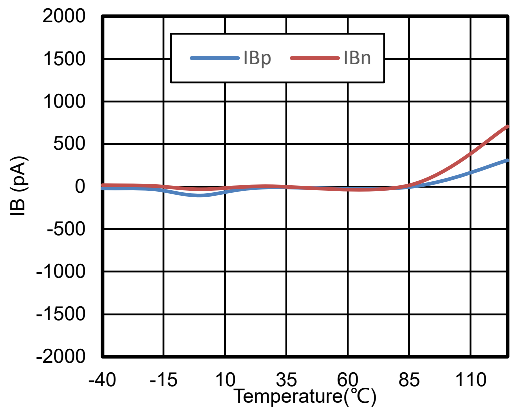


Figure 7. I_B vs Temperature

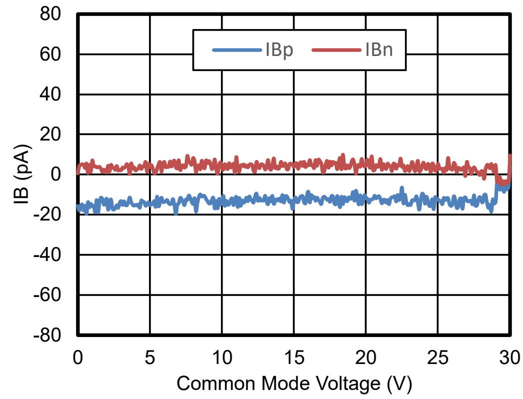


Figure 8. I_B vs V_{CM}

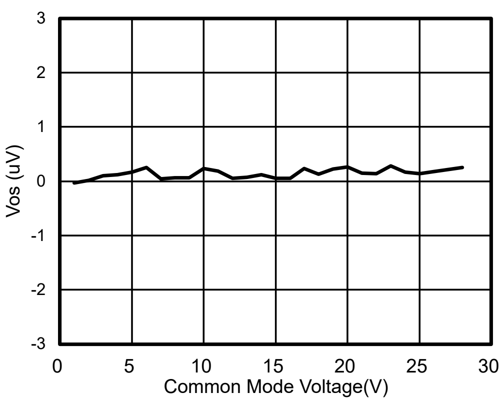


Figure 9. V_{OS} vs V_{CM}, V_S = 30 V

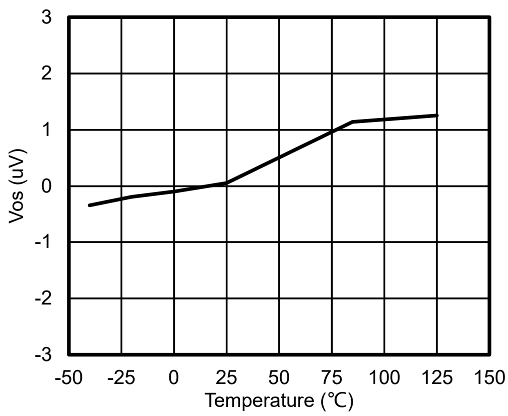


Figure 10. V_{OS} vs Temperature

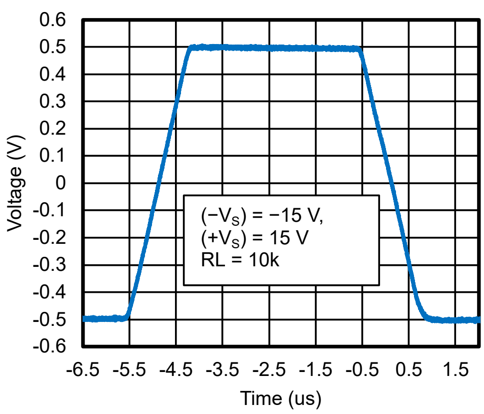


Figure 11. Large Signal Step Response

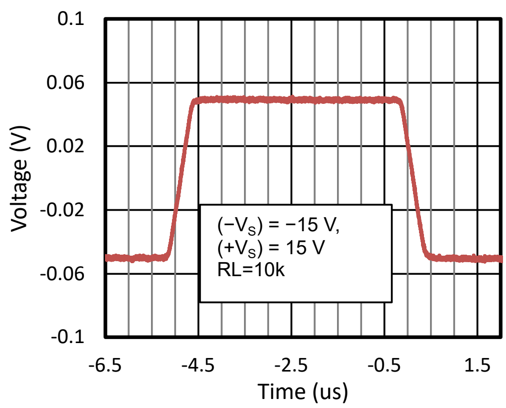


Figure 12. Small Signal Step Response

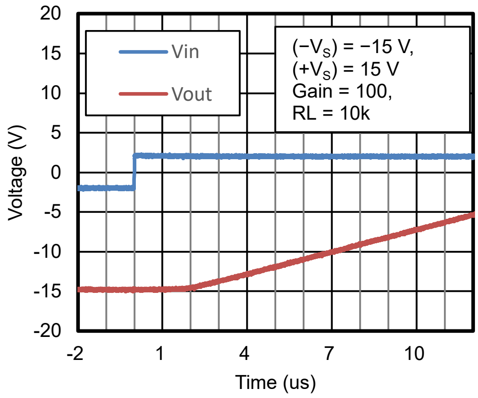


Figure 13. Overload Recovery at Negative Rail

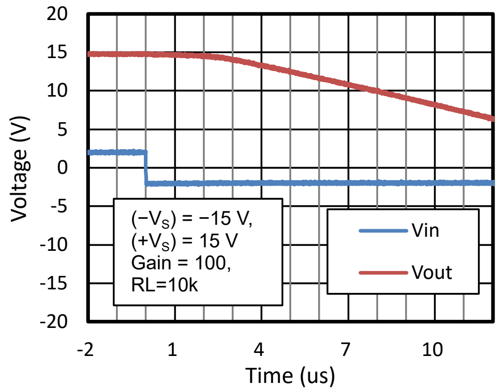


Figure 14. Overload Recovery at Positive Rail

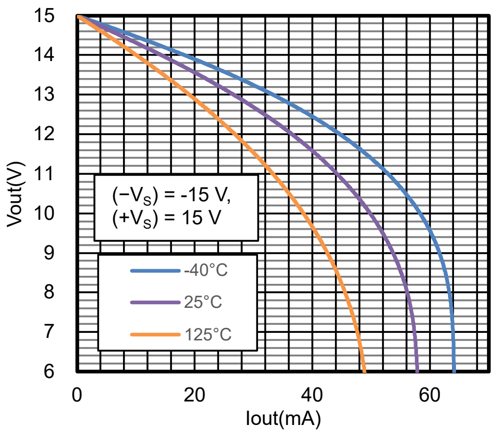


Figure 15. V_{OUT} vs. I_{OUT}, Source

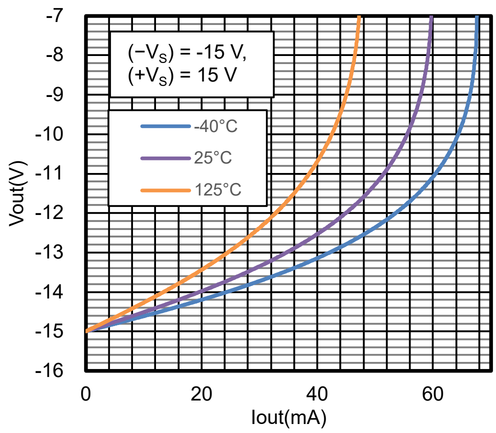


Figure 16. V_{OUT} vs. I_{OUT}, Sink

Detailed Description

Overview

The TPA183x family of zero-drift amplifiers can 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 TPA183x also include 1.1-MHz bandwidth, no 1/f noise, and only 140-uA quiescent current, making the TPA183x suitable for many precision, low power, and temperature sensitive applications. Parameters that can exhibit variance with regard to operating voltage or temperature are presented in Typical Performance Characteristics.

Functional Block Diagram

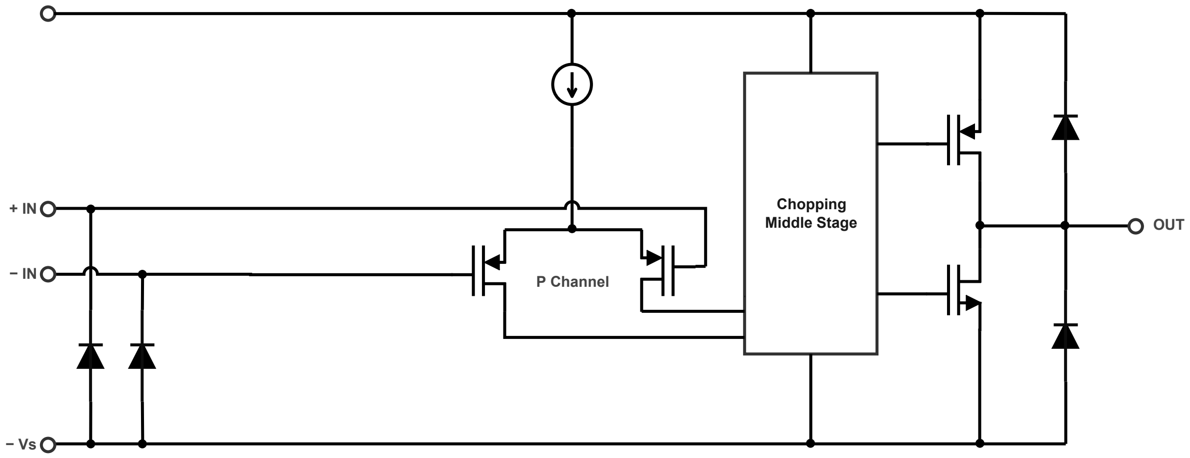


Figure 17. Functional Block Diagram

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 would be ±2 V and the maximum voltage would be ±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-μV offset voltage within the temprature 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 over 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, higher noise spectrum exists at the chopping frequency and its harmonics due to residual ripple.

The devices set the chopping frequency to 125 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 to 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

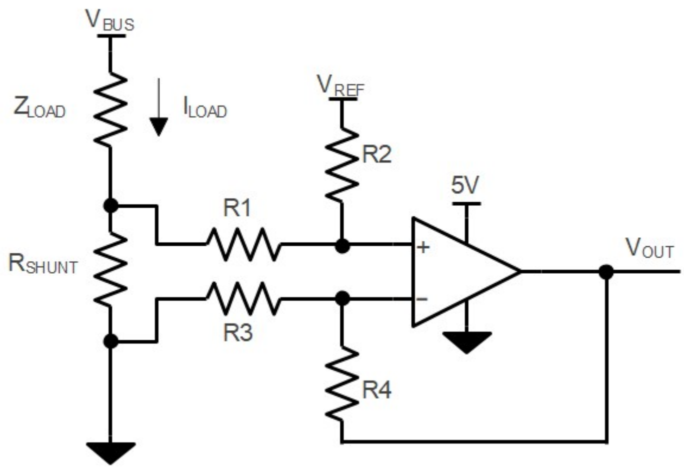
Note

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 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.



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

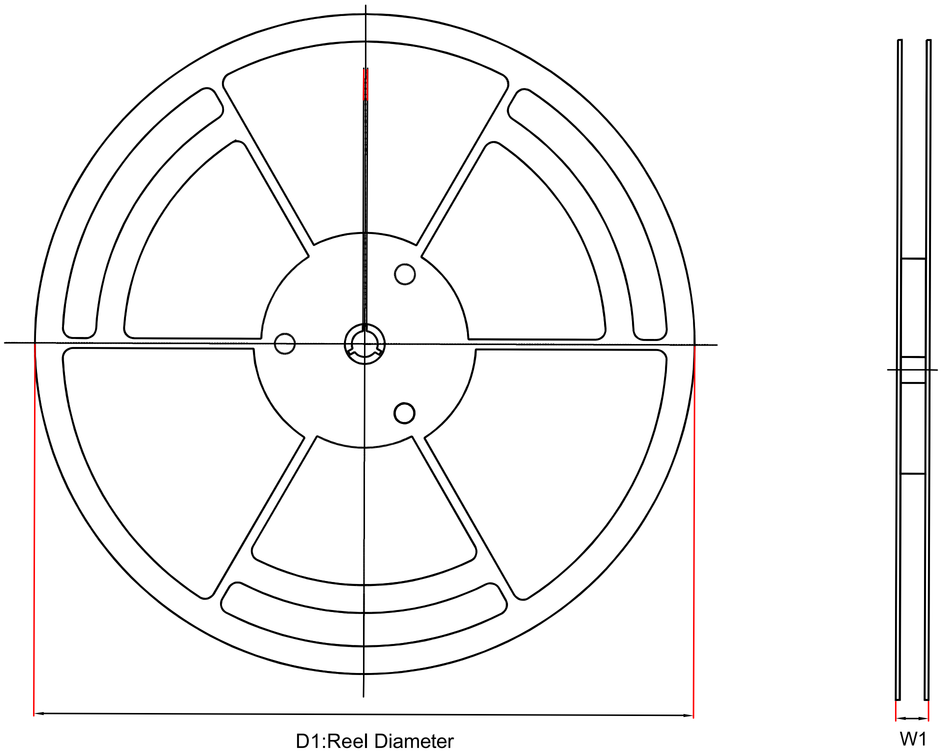
When $R3 = R1$, $R2 = R4$, $R_{SHUNT} \ll R1$

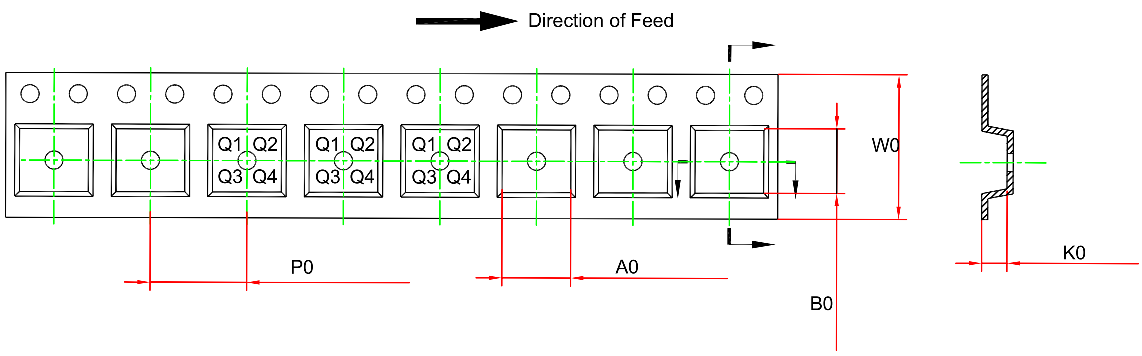
Figure 18. Low-Side Current Sensing Application

Power Supply Recommendations

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

Tape and Reel Information



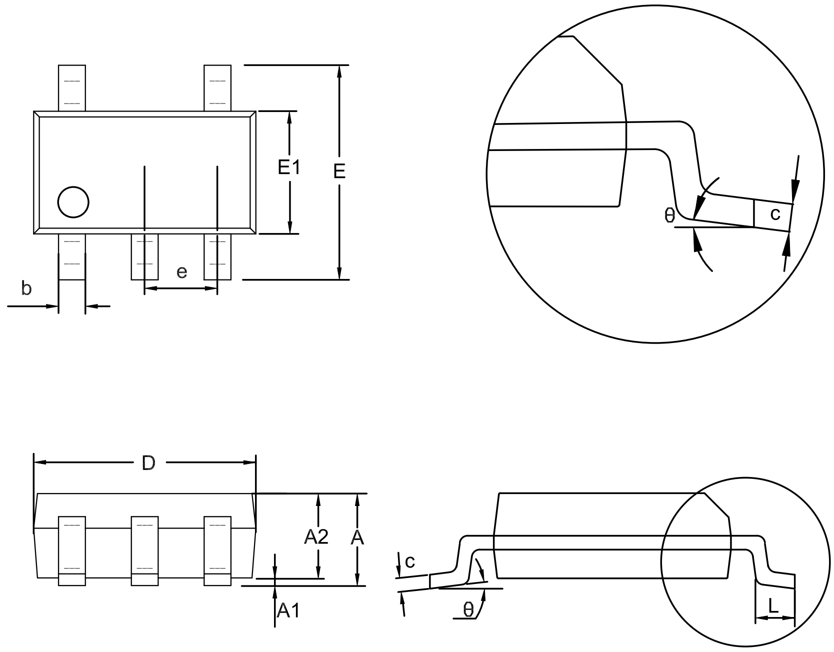


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA1831-S5TR	SOT23-5	179	12	3.3	3.25	1.4	4	8	Q3
TPA1831U-S5TR	SOT23-5	179	12	3.3	3.25	1.4	4	8	Q3
TPA1831-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
TPA1832-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
TPA1832-VS1R	MSOP8	330	17.6	5.3	3.3	1.3	8	12	Q1
TPA1834-SO2R	SOP14	330	21.6	6.5	9.7	1.8	8	16	Q1
TPA1834-TS2R	TSSOP14	330	17.6	6.8	5.5	1.7	8	12	Q1

Package Outline Dimensions

SOT23-5

Package Outline Dimensions S5T(SOT23-5-A)



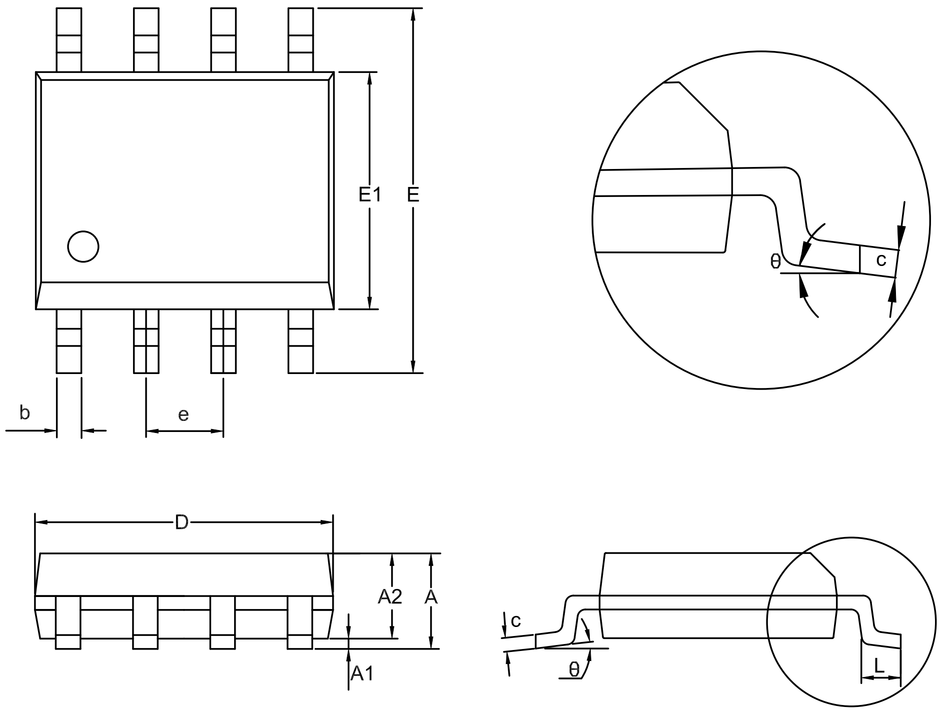
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.280	0.500	0.011	0.020
c	0.100	0.230	0.004	0.009
D	2.820	3.020	0.111	0.119
E	2.600	3.000	0.102	0.118
E1	1.500	1.720	0.059	0.068
e	0.950 BSC		0.037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



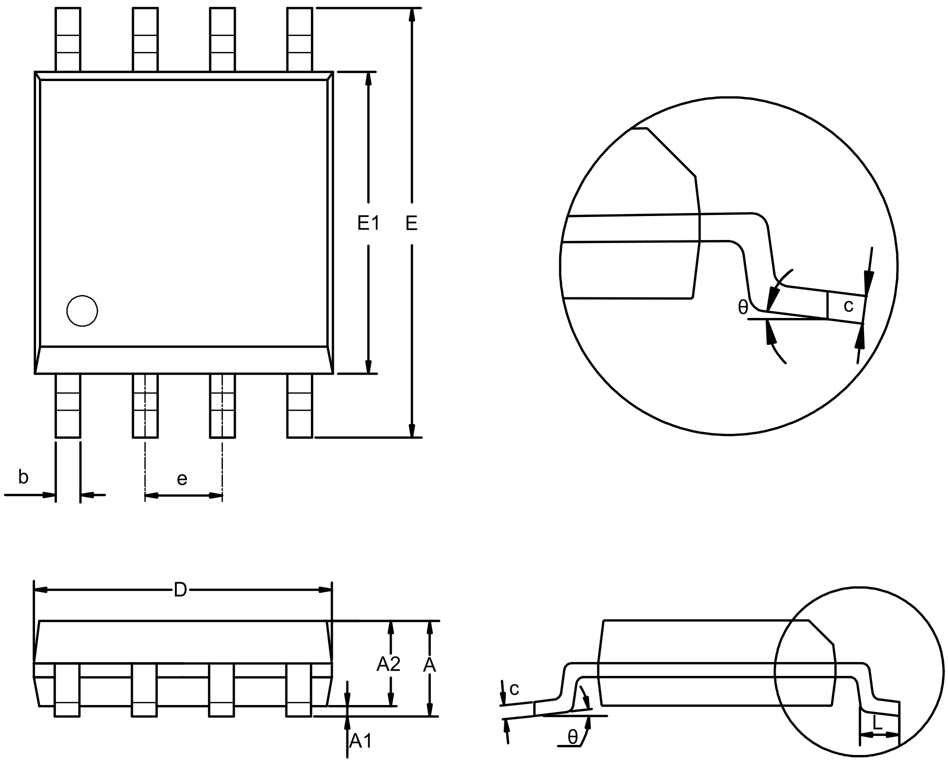
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050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

MSOP8

Package Outline Dimensions VS1(MSOP-8-A)



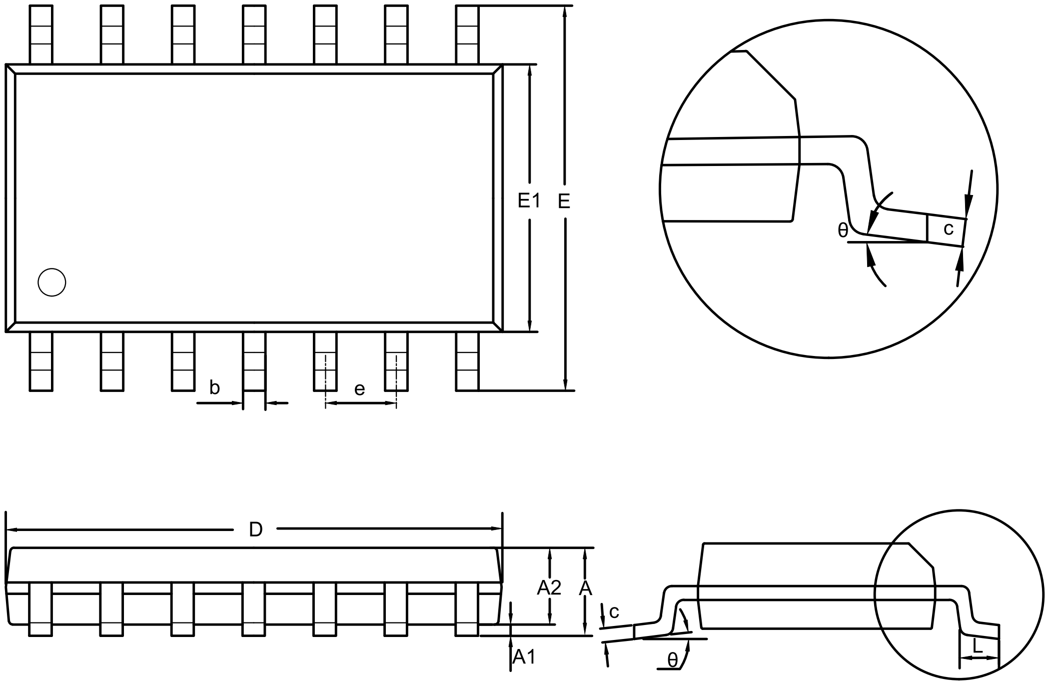
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.650 BSC		0.026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

SOP14

Package Outline Dimensions SO2(SOP-14-A)



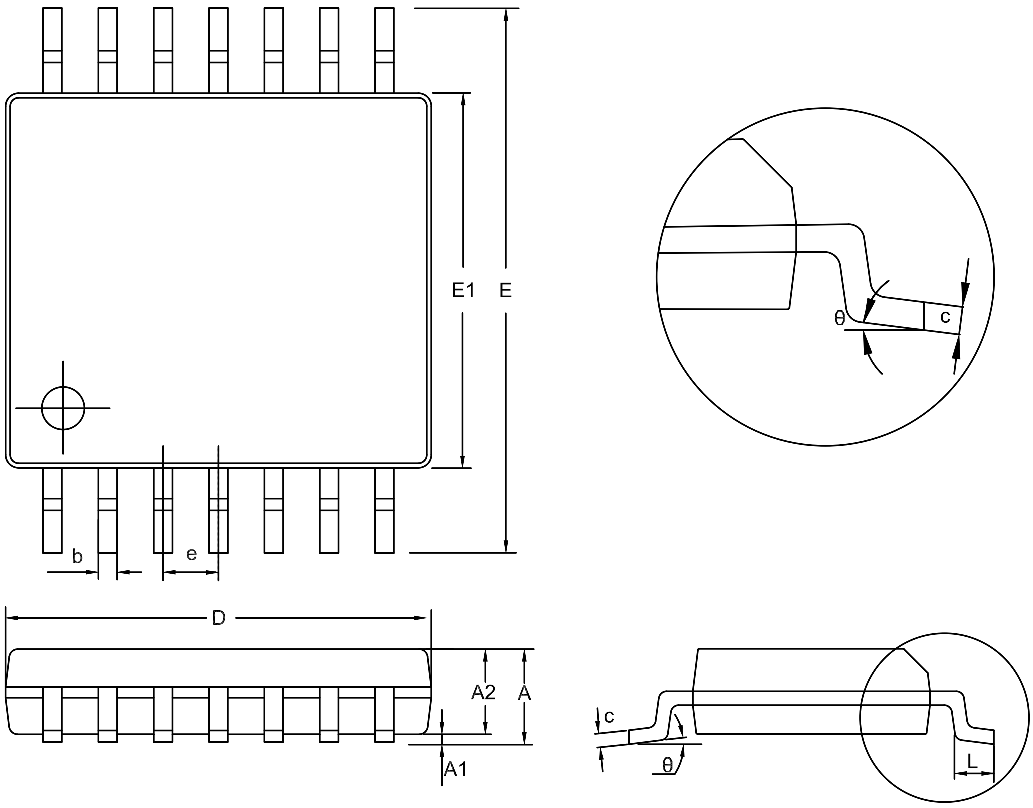
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.650	0.049	0.065
b	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D	8.450	8.850	0.333	0.348
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 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
TPA1831-S5TR	−40 to 125°C	SOT23-5	183	MSL3	Tape and Reel,3000	Green
TPA1831U-S5TR (1)	−40 to 125°C	SOT23-5	83U	MSL3	Tape and Reel,3000	Green
TPA1831-SO1R	−40 to 125°C	SOP8	A1831	MSL3	Tape and Reel,4000	Green
TPA1832-SO1R	−40 to 125°C	SOP8	A1832	MSL3	Tape and Reel,4000	Green
TPA1832-VS1R (1)	−40 to 125°C	MSOP8	A1832	MSL3	Tape and Reel,3000	Green
TPA1834-SO2R	−40 to 125°C	SOP14	A1834	MSL3	Tape and Reel,2500	Green
TPA1834-TS2R	−40 to 125°C	TSSOP14	A1834	MSL3	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.

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