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

Features

- Supply Voltage: 4 V to 30 V
- Low Power: Typical 55 μA at 25°C
- Low Offset Voltage: ±8 μV Maximum at 25°C
- Zero Drift: ±0.01 μV/°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

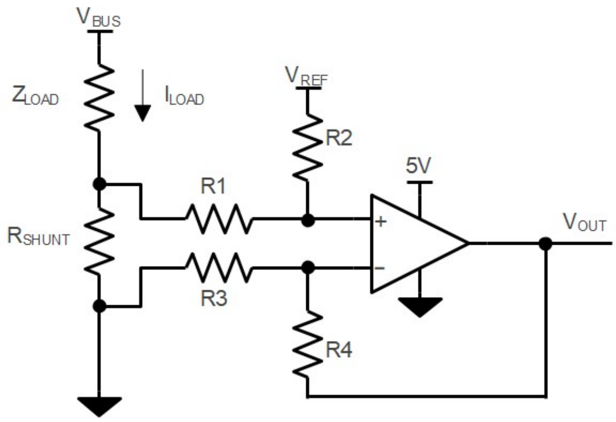
Description

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

The TPA181x series of devices provide rail-to-rail input and output. These devices have excellent AC performance with 500-kHz bandwidth and 0.3-V/us slew rate while only drawing 55-uA quiescent current per amplifier.

All versions can be operated over the industrial temperature range from −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, $R_{SHUNT} << R1$

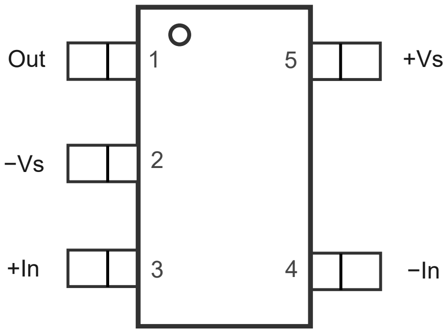
Table of Contents

Revision History

Date	Revision	Notes
2024-07-16	Rev.A.0	Initial version.

Pin Configuration and Functions

TPA1811
SOT23-5 Package
Top View



TPA1811
SOP8 Package
Top View

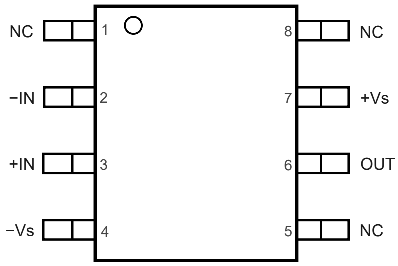
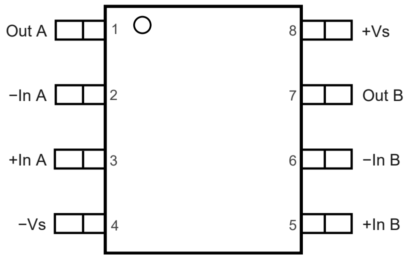


Table 1. Pin Functions: TPA1811

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

TPA1812
SOP8 Package
Top View



TPA1812
MSOP8 Package
Top View

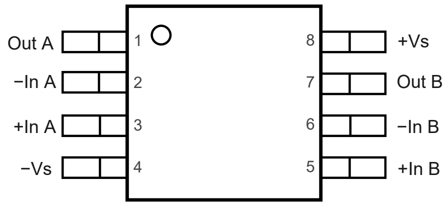


Table 2. Pin Functions: TPA1812

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

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
	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	
T_J	Maximum Operating 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

Electrical Characteristics

Test conditions: 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	$(+V_S) – (−V_S)$	4		30	V
I_Q	Quiescent Current per Amplifier	V_S = 30 V		55	95	μA
		V_S = 30 V, T_A = −40°C to 125°C			120	μA
		V_S = 4 V		45	70	μA
		V_S = 4 V, T_A = −40°C to 125°C			90	μA
PSRR	Power Supply Rejection Ratio	V_S = 16 V to 30 V	125	150		dB
		V_S = 16 V to 30 V, T_A = −40°C to 125°C	115			dB
Input Characteristics						
V_{OS}	Input Offset Voltage	V_S = 30 V, V_{CM} = 15 V	-8	1	8	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	-8	1	8	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 = 30 V, V_{CM} = 15 V (1)		50	400	pA
		V_S = 30 V, V_{CM} = 15 V, T_A = −40°C to 125°C (1)			800	pA
		V_S = 4 V, V_{CM} = 2 V		50	400	pA
		V_S = 4 V, V_{CM} = 2 V, T_A = −40°C to 125°C			800	pA
I_{OS}	Input Offset Current	V_S = 30 V, V_{CM} = 15 V (1)		50	400	pA
		V_S = 30 V, V_{CM} = 15 V, T_A = −40°C to 125°C (1)			800	pA
		V_S = 4 V, V_{CM} = 2 V		50	400	pA
		V_S = 4 V, V_{CM} = 2 V, T_A = −40°C to 125°C			800	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	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 = −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 test and design simulation.
(2) Provided by design simulation.

Typical Performance Characteristics

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

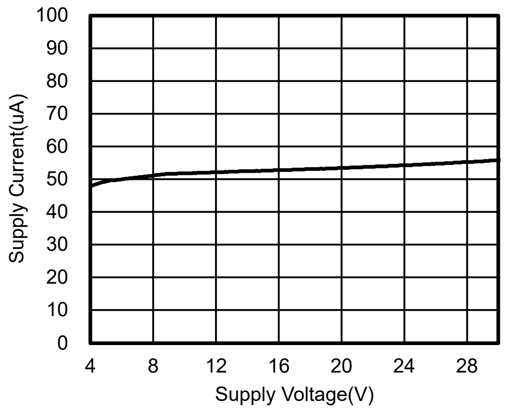


Figure 1. Supply Current vs Supply Voltage

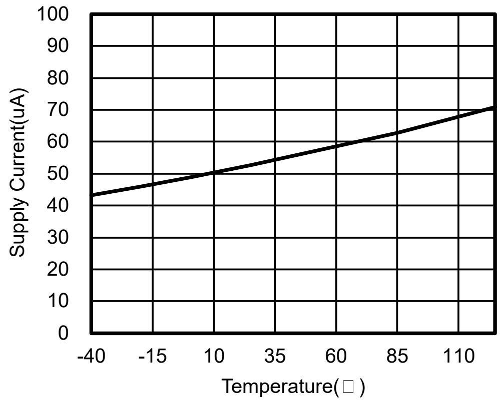


Figure 2. Supply Current vs Temperature

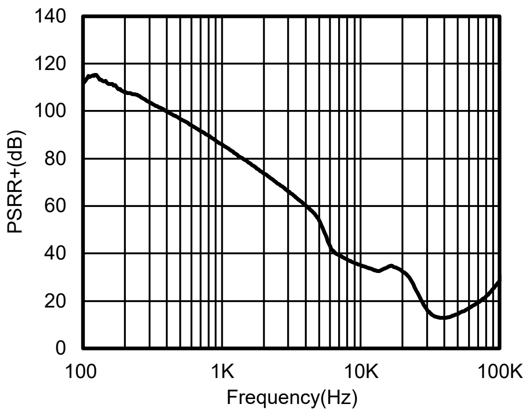


Figure 3. PSRR+ vs Frequency

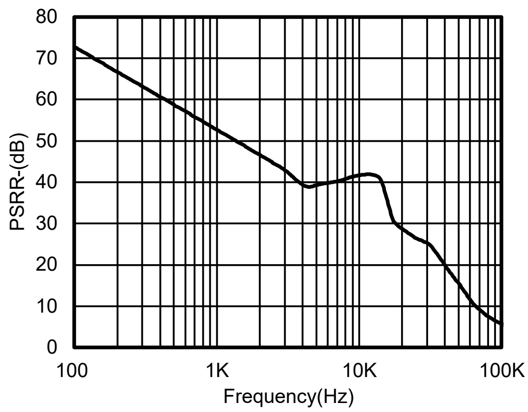


Figure 4. PSRR- vs Frequency

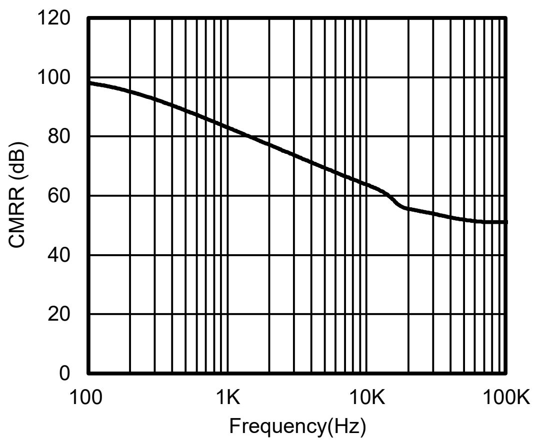


Figure 5. CMRR vs Frequency

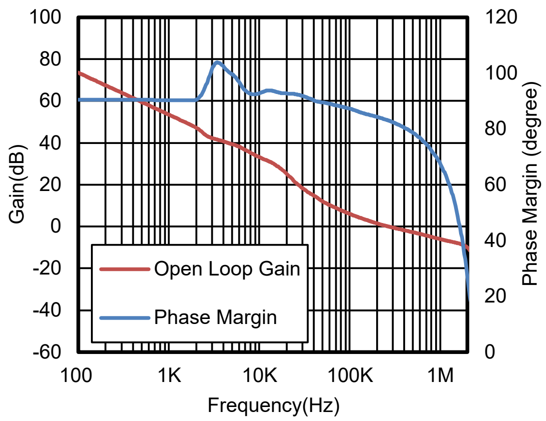


Figure 6. Open Loop Gain and Phase Margin vs Frequency, RL = 10 kΩ

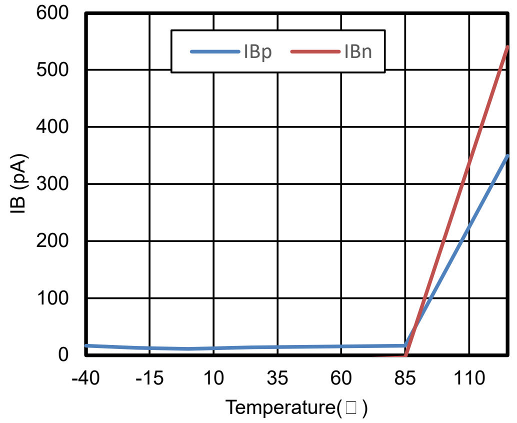


Figure 7. I_B vs Temperature

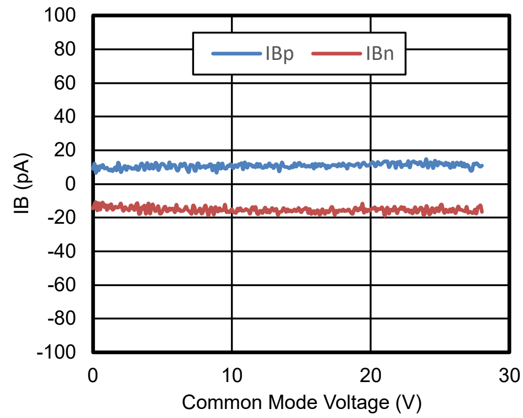


Figure 8. I_B vs V_{CM}

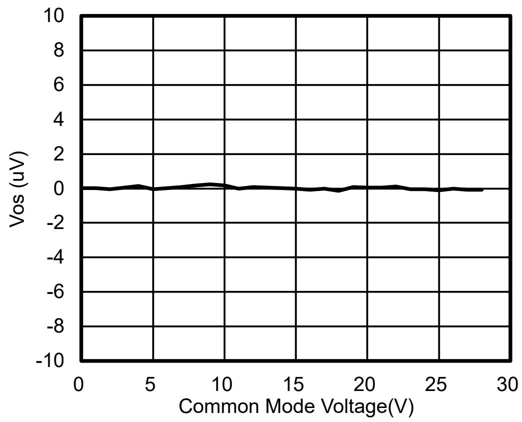


Figure 9. V_{OS} vs V_{CM}, V_S = 30 V

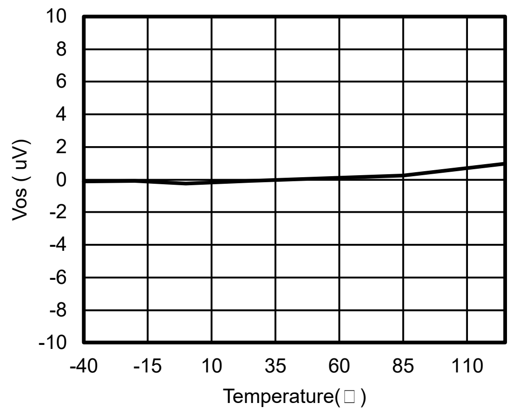


Figure 10. V_{OS} vs Temperature

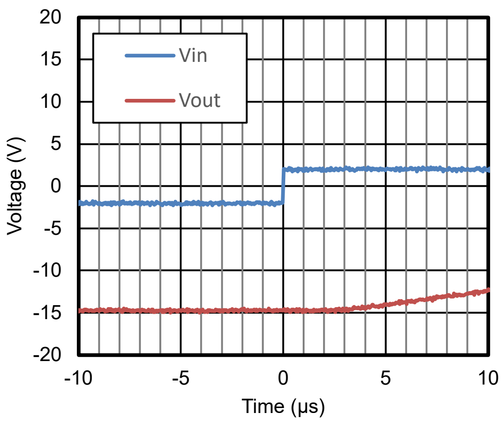


Figure 11. Overload Recovery at Negative Rail

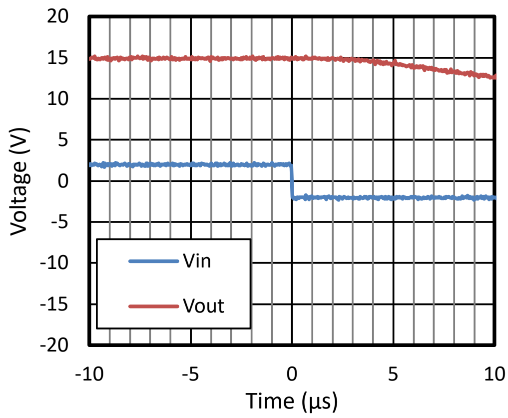


Figure 12. Overload Recovery at Positive Rail

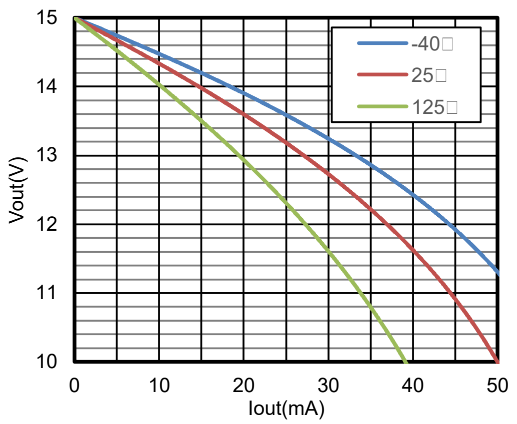


Figure 13. Output Voltage vs Output Current, Source, (−VS) = −15 V, (+VS) = 15 V

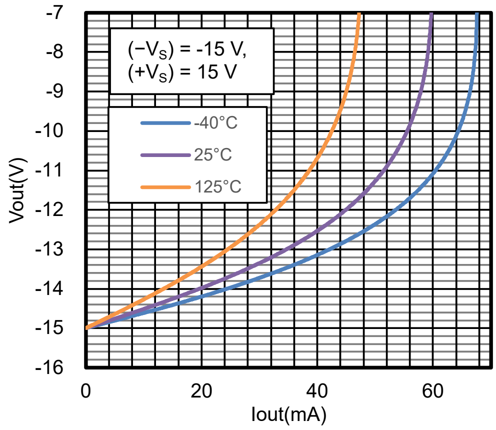


Figure 14. Output Voltage vs Output Current, Sink, (−VS) = −15 V, (+VS) = 15 V

Detailed Description

Overview

The TPA181x 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 TPA181x also include 500-kHz bandwidth, no 1/f noise, and only 55-uA quiescent current, making the TPA181x 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

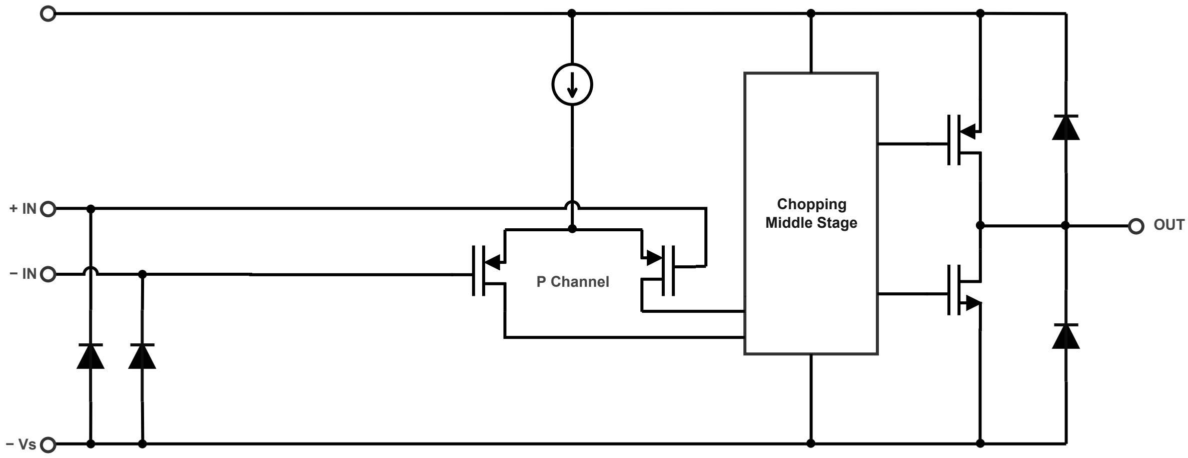


Figure 15. Functional Block Diagram

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 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 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 100kHz. 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

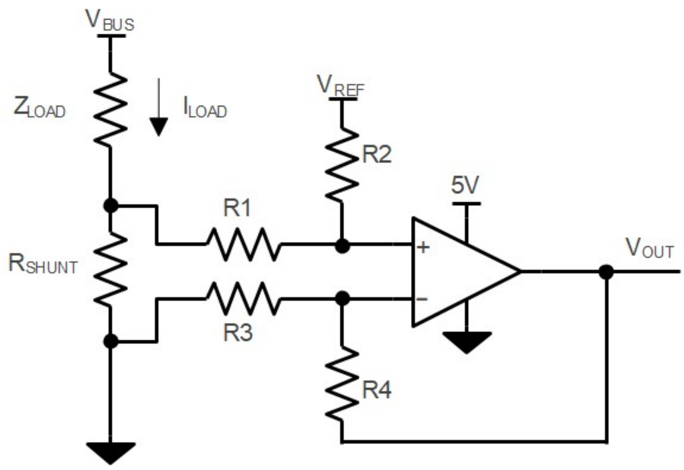
Note

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. 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.



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

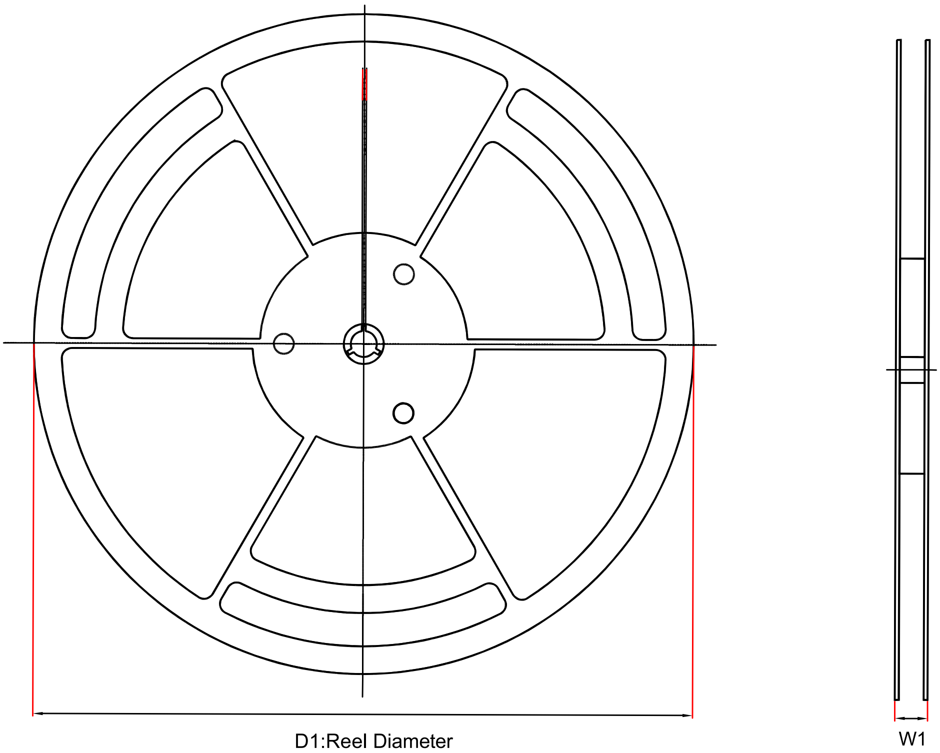
When R3 = R1, R2 = R4, R_{SHUNT} << R1

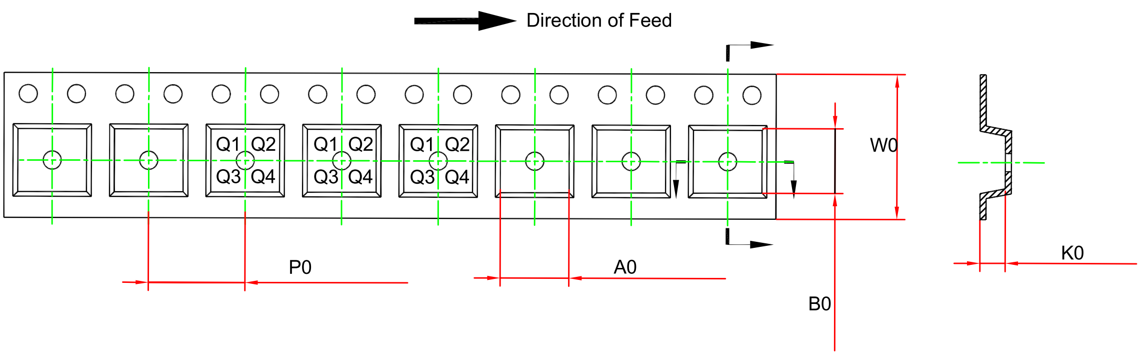
Figure 16. Low-Side Current Sensing Application

Power Supply Recommendations

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

Tape and Reel Information



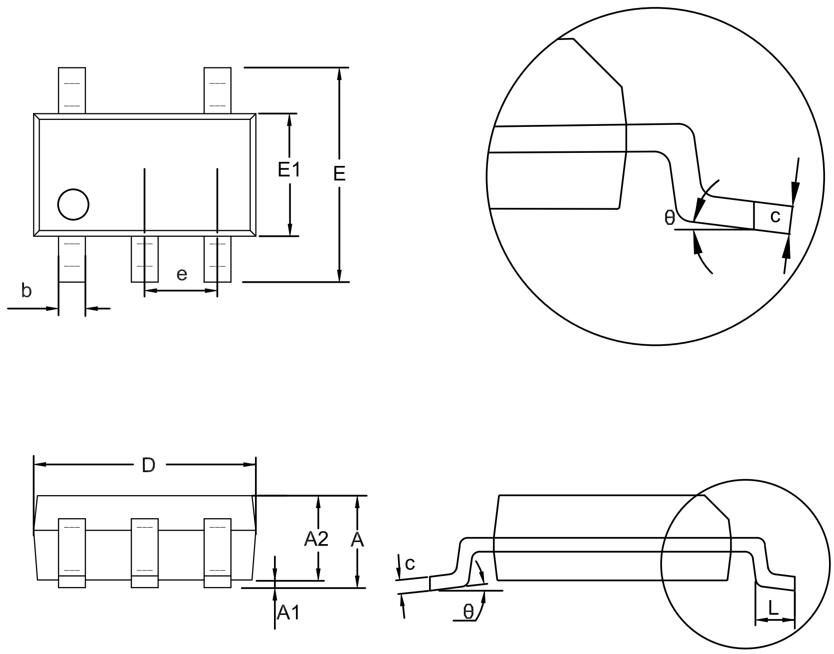


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA1811-S5TR	SOT23-5	180.0	12	3.3	3.25	1.4	4.0	8.0	Q3
TPA1811-SO1R	SOP8	330.0	17.6	6.5	5.4	2.0	8.0	12.0	Q1
TPA1812-SO1R	SOP8	330.0	17.6	6.5	5.4	2.0	8.0	12.0	Q1
TPA1812-VS1R	MSOP8	330.0	17.6	5.3	3.4	1.3	8.0	12.0	Q1

Package Outline Dimensions

SOT23-5

Package Outline Dimensions S5T(SOT23-5-A)



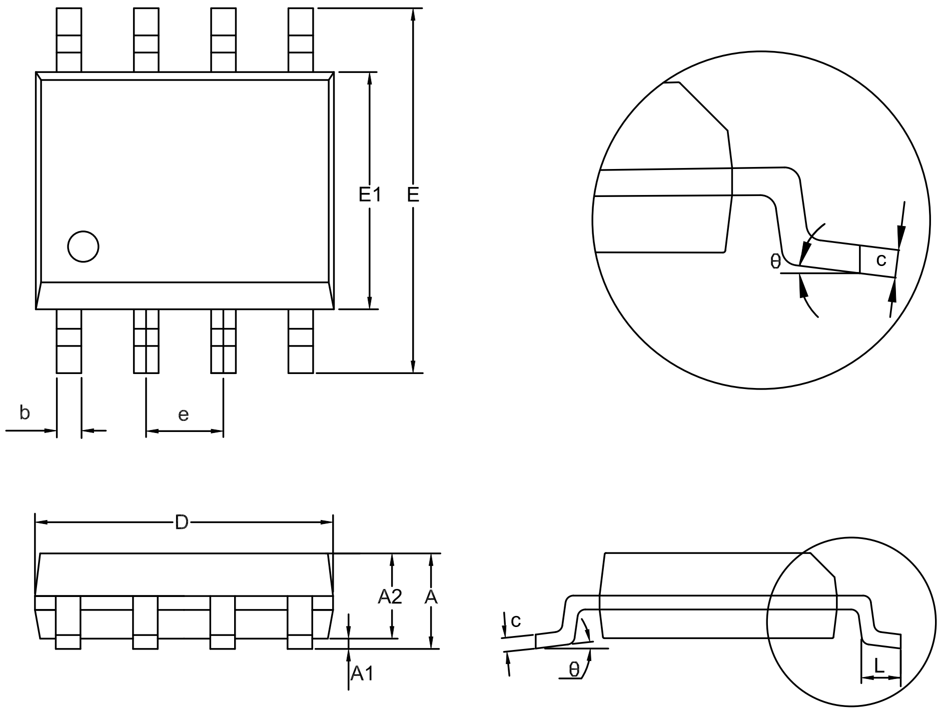
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.280	0.500	0.011	0.020
c	0.100	0.230	0.004	0.009
D	2.820	3.020	0.111	0.119
E	2.600	3.000	0.102	0.118
E1	1.500	1.720	0.059	0.068
e	0.950 BSC		0.037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



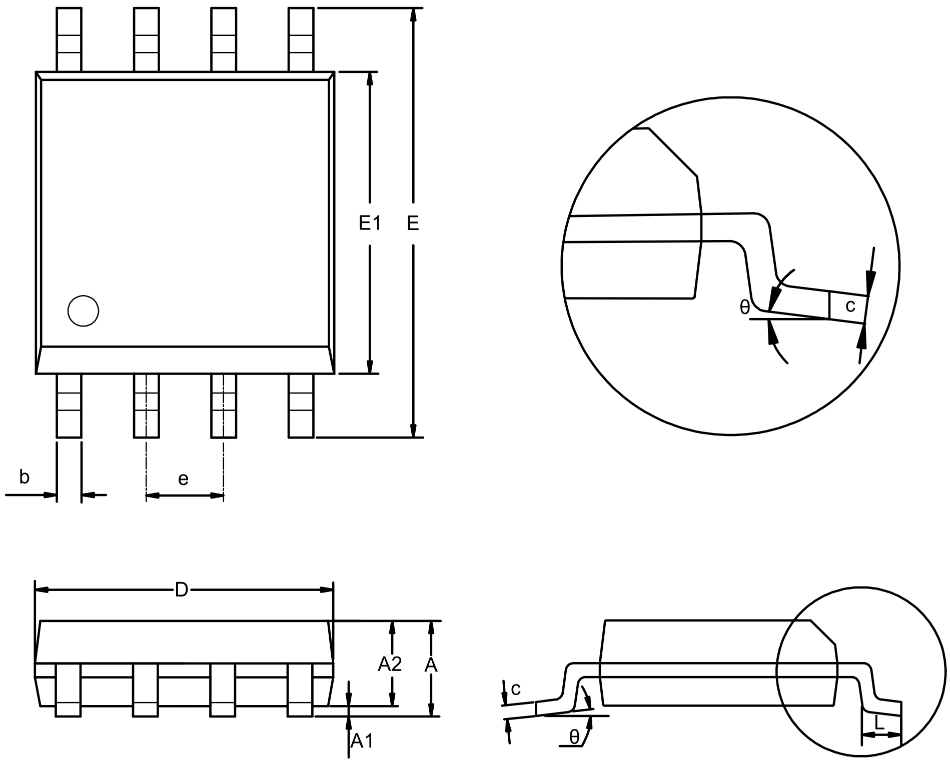
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050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

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	MSL3	Tape and Reel,3000	Green
TPA1811-SO1R	−40 to 125°C	SOP8	A1811	MSL3	Tape and Reel,4000	Green
TPA1812-SO1R	−40 to 125°C	SOP8	A1812	MSL3	Tape and Reel,4000	Green
TPA1812-VS1R	−40 to 125°C	MSOP8	A1812	MSL3	Tape and Reel,3000	Green

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

IMPORTANT NOTICE AND DISCLAIMER

Performance Information. Performance tests or performance range contained in this document/material are either results of design simulation or actual tests conducted under designated testing environment. Any variation in testing environment or simulation environment, including but not limited to testing method, testing process or testing temperature, may affect actual performance of the product.

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