275-V Common Voltage Difference Amplifier

Features

- Supply Voltage: 4.5 V to 36 V (±2.25 V to ±18 V)
- Offset Voltage: ±1 mV (Max)
- Gain Error: 0.03% (Max)
- Bandwidth: 500 kHz, Slew Rate: 10 V/μs
- EMI Enhancement
- Operating Temperature Range: −40℃ to 125℃

Applications

- Current Sense on High Common Voltage
- Battery Voltage Monitor
- Industrial Control

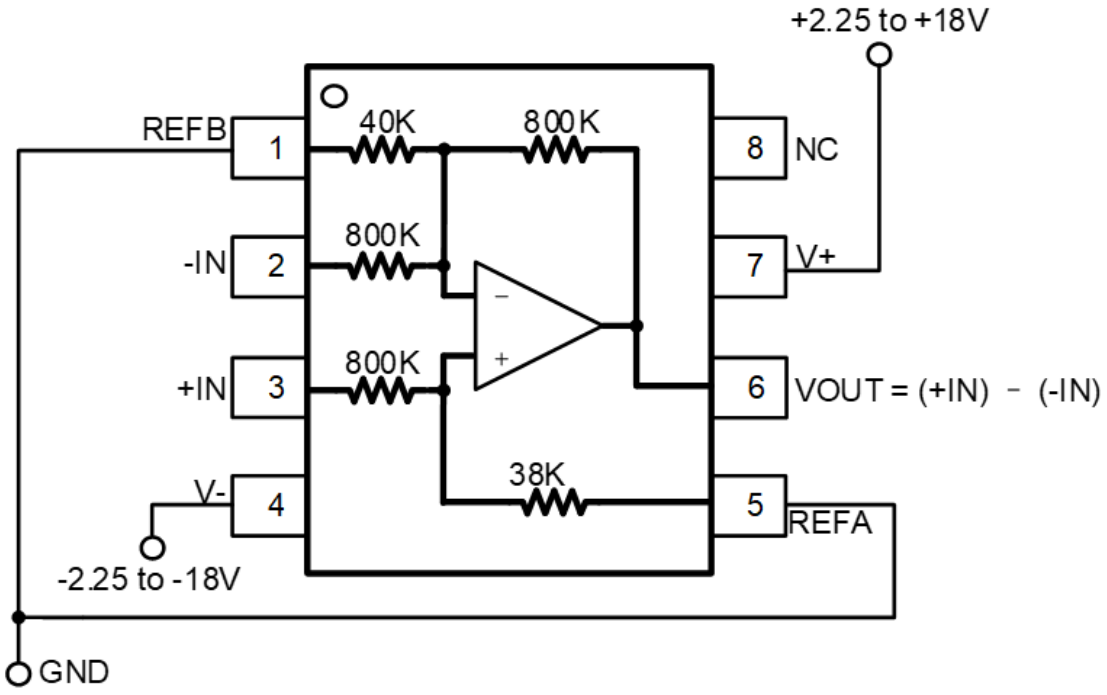
Description

The devices are general-purpose, unity-gain difference amplifiers for precision signal conditioning from −275-V to 275-V common voltage range. The on-chip resistors are trimmed for excellent gain accuracy and high CMRR over the operating temperature range.

The TPA9151 has two reference input pins. The TPA9152 has one reference input pin at pin 1, and leaves pin 5 to NC (not connected).

The devices can be used to replace isolation amplifiers in applications where the galvanic isolation is not required.

Typical Application Circuit



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Revision History

Date	Revision	Notes
2021-07-20	Rev.A.0	Initial version
2021-08-31	Rev.A.1	Updated description in ESD section
2024-01-29	Rev.A.2	Added TPA9152 and TPA9151B
2024-12-18	Rev.A.3	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.

Pin Configuration and Functions

TPA9151
SOP8
Top View

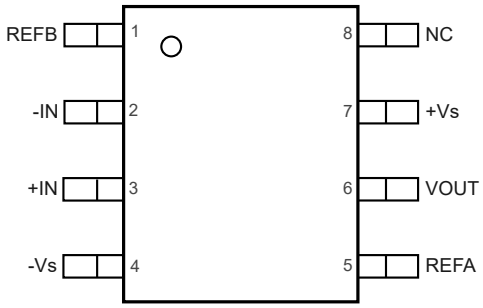


Table 1. Pin Functions: TPA9151

Pin		I/O	Description
No.	Name		
1	REFB	I	Reference input B
2	−IN	I	Inverting input
3	+IN	I	Non-inverting input
4	$-V_S$	Power Supply	Negative power supply (1)
5	REFA	I	Reference input A
6	VOUT	O	Output
7	$+V_S$	Power Supply	Positive power supply (1)
8	NC		Not connected

(1) In this document, $(+V_S) - (-V_S)$ is referred to V_S.

TPA9152
SOP8
Top View

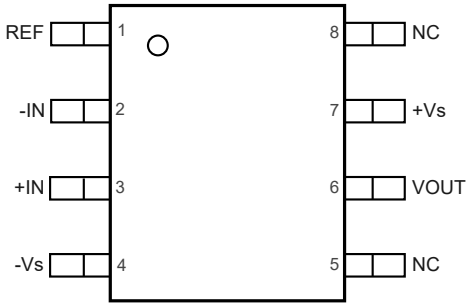


Table 2. Pin Fuctions: TPA9152

Pin		I/O	Description
No.	Name		
1	REF	I	Reference input
2	−IN	I	Inverting input
3	+IN	I	Non-inverting input
4	$-V_S$	Power Supply	Negative power supply (1)
5	NC		Not connected
6	VOUT	O	Output
7	$+V_S$	Power Supply	Positive power supply (1)
8	NC		Not connected

(1) In this document, $(+V_S) - (-V_S)$ is referred to V_S.

Specifications

Absolute Maximum Ratings (1)

Parameter		Min	Max	Unit
	Supply Voltage		40	V
	Input Voltage Range, Continuous		300	V
	Reference Input Voltage	$(-V_S) - 0.3$	$(+V_S) + 0.3$	V
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.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001 (1), V_{OUT} to $(+V_S)$ or $(-V_S)$, $(+V_S)$ to $(-V_S)$	4	kV
		ANSI/ESDA/JEDEC JS-001 (1), +IN or –IN to $(+V_S)$ or $(-V_S)$	1	kV
		ANSI/ESDA/JEDEC JS-001 (1), REF_A	400	V
		ANSI/ESDA/JEDEC JS-001 (1), REF_B	500	V
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.

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
SOP8	158	43	°C/W

Electrical Characteristics

All test conditions: ($+V_S$) = +15 V, ($-V_S$) = −15 V, R_L = 10 kΩ to ground, REF_A = REF_B = GND, T_A = 25°C, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Power Supply						
V_S	Supply Voltage Range		±2.25		±18	V
I_Q	Quiescent Current	V_{OUT} = 0 V		2	3	mA
		V_{OUT} = 0 V, T_J = −40°C to 125°C			3.5	mA
Gain						
	Initial	V_{OUT} = ±10 V, R_L = 10 kΩ		1		V/V
GE	Gain Error	V_{OUT} = ±10 V, R_L = 10 kΩ		0.02	0.03	%FSR
		V_{OUT} = ±10 V, R_L = 10 kΩ, T_J = −40°C to 125°C			0.05	%FSR
	Gain Drift	V_{OUT} = ±10 V, R_L = 10 kΩ, T_J = −40°C to 125°C		5		PPM/℃
	Nonlinearity	V_{OUT} = ±10 V, R_L = 10 kΩ		0.002		%FSR
Offset Voltage						
V_{OS}	Input Offset Voltage	V_{CM} = 0 V	−1	0.05	1	mV
		V_{CM} = 0 V, T_J = −40°C to 125°C	−2		2	mV
$V_{OS}TC$	Offset Voltage Drift	V_{CM} = 0 V, T_J = −40°C to 125°C		2		μV/°C
PSRR	Power Supply Rejection Ratio	V_S = ±2.25 V to ±18 V, V_{CM} = 0 V, V_{DM} = 0 V	90	120		dB
Input						
	Impedance	Differential mode		1600		kΩ
		Commom mode		400		kΩ
	Voltage Range	Differential mode	−13.5		13.5	V
		Common mode, HTOL test	−200		200	V
CMRR	Common-Mode Rejection Ratio	V_{CM} = ±275 V, production Test	80	90		dB
		V_{CM} = ±275 V, production Test, T_J = −40°C to 125°C	78			dB
		V_{CM} = 0 V to 60 V, TPA9151	80	95		dB
		V_{CM} = 0 V to 60 V, TPA9151A	90	96		dB
		V_{CM} = −30 V to 40 V, TPA9151B	96			dB
Output						
	Output Swing from Supply Rail	R_L = 10 kΩ to V_S / 2		50	200	mV
		R_L = 2 kΩ to V_S / 2		400	500	mV
I_{SC}	Output Short-Circuit Current			100		mA

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
AC Specifications						
GBW	Gain-Bandwidth Product			500		kHz
SR	Slew Rate	10-V step		10		V/μs

Typical Performance Characteristics

All test conditions: V_S = 30 V, T_A = +25°C, unless otherwise noted.

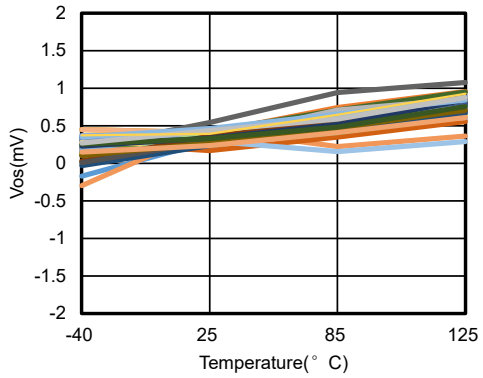


Figure 1. V_{OS} vs. Temperature, V_S = 30 V, V_{CM} = 15 V

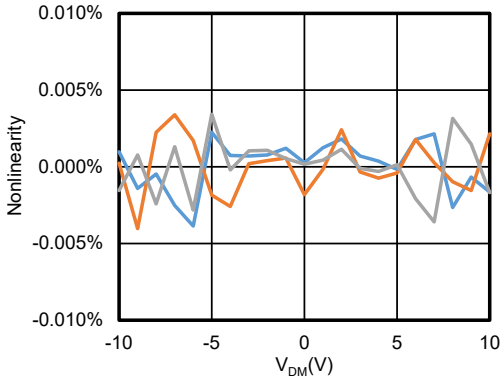


Figure 2. Nonlinearity

Detailed Description

Overview

The TPA9151 and TPA9152 integrate on-chip matching resistors with high-precision amplifiers to achieve excellent gain accuracy, linearity, and CMRR over the operating temperature range. The resistors also extend the input signal range beyond the power supply rail.

Functional Block Diagram

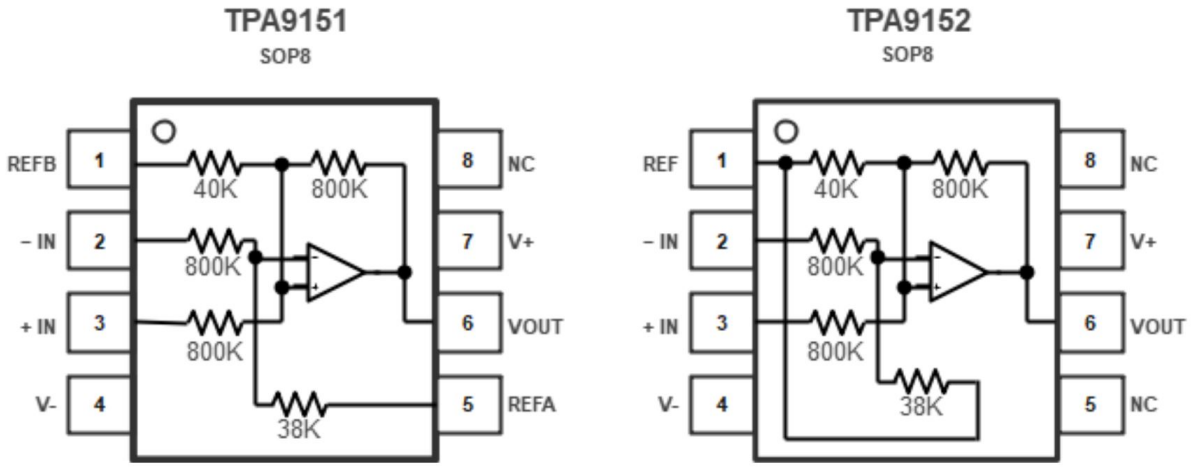


Figure 3. Functional Block Diagram

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

Transfer Function

The complete transfer function of the TPA9151 is given in Equation 1.

$$V_{OUT} = (+IN) - (-IN) + 20 \times REF_A - 19 \times REF_B \quad (1)$$

Usually, REF_A and REF_B are tied to the same voltage level, and recorded as REF, so the transfer function is Equation 2. REF_A and REF_B are tied to pin 1 internally in the TPA9152.

$$V_{OUT} = (+IN) - (-IN) + REF \quad (2)$$

Basic Connections

Figure 4 shows the basic connections for dual-supply operation. Figure 5 shows the basic connections for single-supply operation. 0.1-μF decoupling capacitors are recommended to be placed close to the power supply pins of the device.

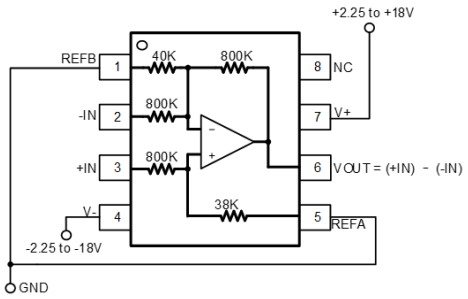


Figure 4. Dual-Supply Operation Connections

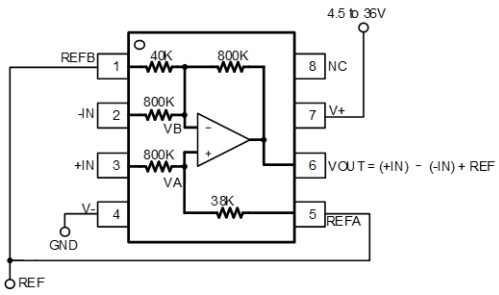


Figure 5. Single-Supply Operation Connections

Common-Mode Input Range

The high common-mode range of the device is achieved by dividing up the input signal with the resistor divider. This resistor divider brings both the positive input (+IN) and the negative input (−IN) within the input range of the internal operational amplifier. V_A and V_B are the inputs of the internal operational amplifier in Figure 5, which can be calculated by the voltage at the (−IN), (+IN), REFA, REFB, ($+V_S$), and ($-V_S$) pins when the device works in the close loop. V_A and V_B can swing to the negative power rail and 1.5 V less than positive power rail, so the common-mode input range at the (+IN) input can be calculated by Equation 3.

$$V_{CM} = (800 + 38) / 38 \times (V_A \text{ or } V_B) - 800 / 38 \times REF_A \cong 22 \times (V_A \text{ or } V_B) - 21 \times REF_A \quad (3)$$

Some calculated cases are shown in Table 3, and please note that the voltage range from +275 V to −275 V is guaranteed by the production test, and that the voltage range from +200 V to −200 V is guaranteed by the HTOL test.

Table 3. Common Voltage Range with Different Supply Voltage and Reference Voltage

$+V_S$	$-V_S$	REF_A	V_A or V_B		V_{CM}	
			Min	Max	Min	Max
15	–15	0	−15	13.5	−330	297
30	0	15	0	28.5	−315	312
10	–10	0	−10	8.5	−220	187
10	0	5	0	8.5	−105	82

Differential Input Range

When the voltage at the (+IN) pin is within the range calculated by Equation 3, the voltage at the (–IN) pin can be determined by V_{OUT}, REF_A, and REF_B from Equation 4 which is derived from Equation 2. V_{OUT} must be kept in the output range of the internal amplifier. V_{OUT} can reach negative and positive power rails.

$$(-IN) = (+IN) - V_{OUT} + REF \quad (4)$$

Typical Application

Figure 6 shows the typical application schematic.

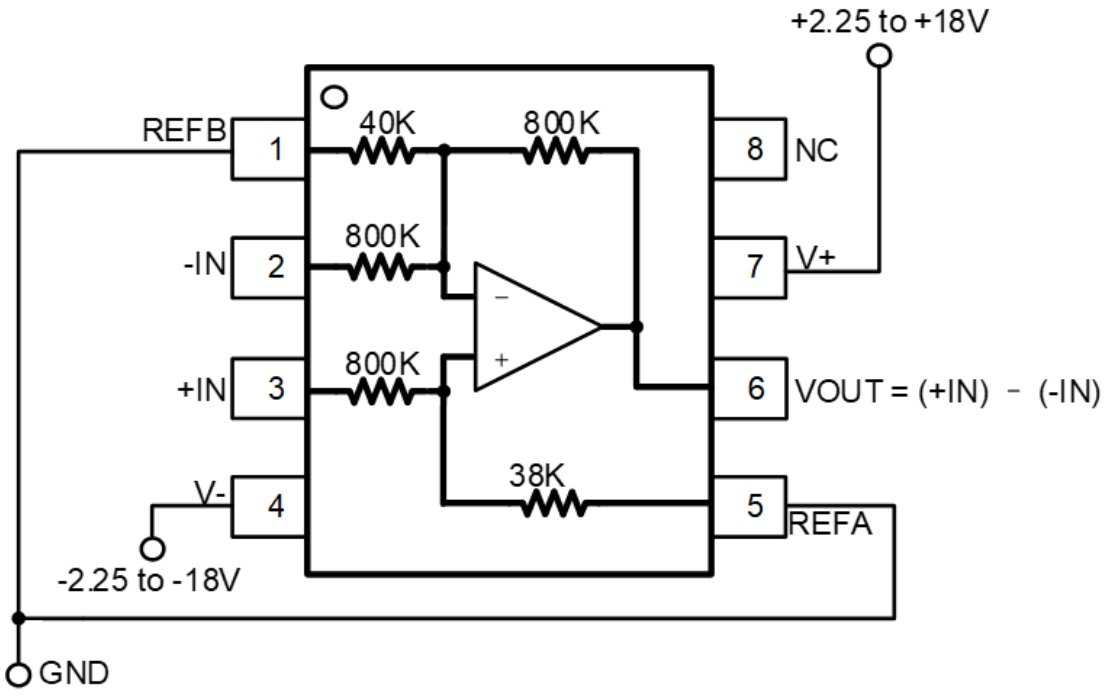
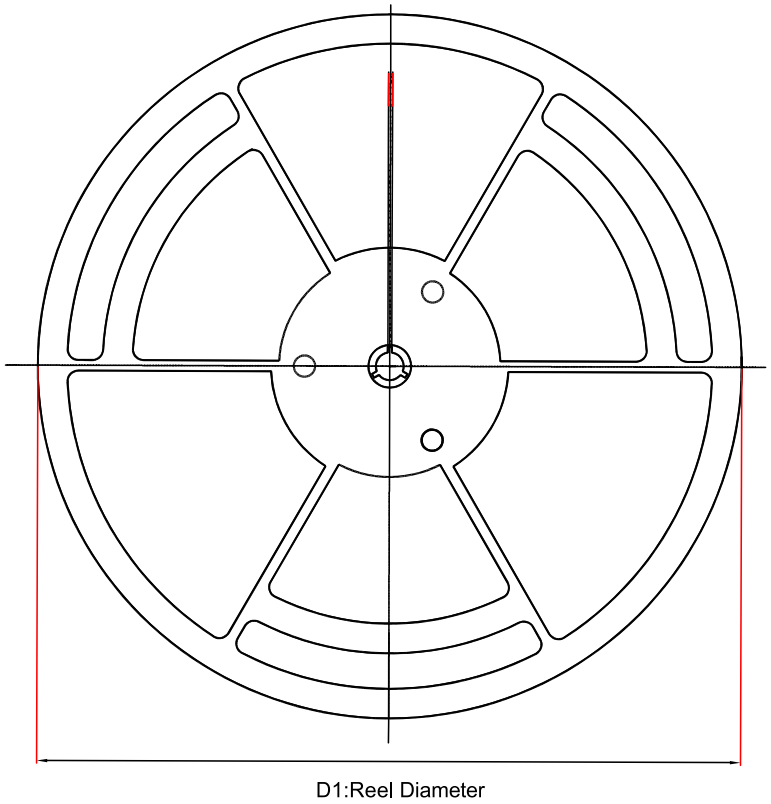
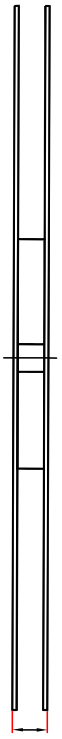
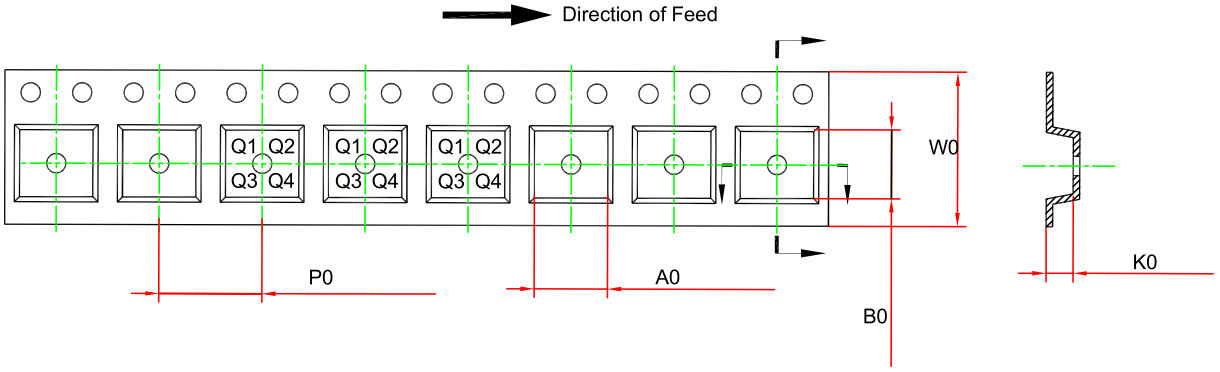


Figure 6. Typical Application Circuit

Tape and Reel Information







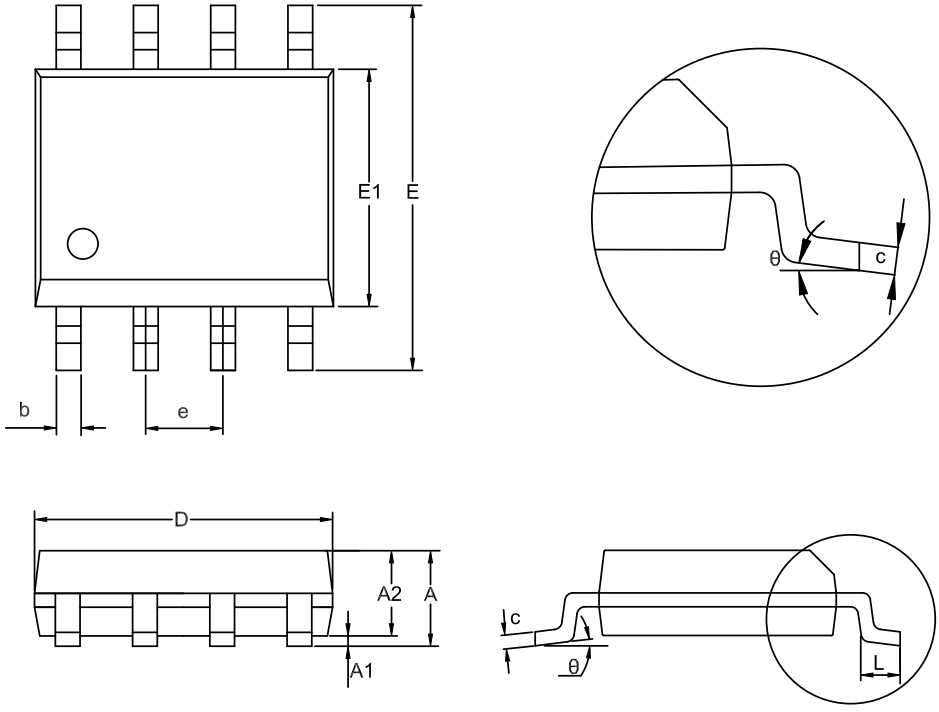
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) (1)	B0 (mm) (1)	K0 (mm) (1)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA9151A-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
TPA9151B-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
TPA9151-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
TPA9152-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1

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

Package Outline Dimensions

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.

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPA9151-SO1R	−40 to 125°C	SOP8	A9151	3	Tape and Reel, 4000	Green
TPA9151A-SO1R	−40 to 125°C	SOP8	A9151	3	Tape and Reel, 4000	Green
TPA9151B-SO1R	−40 to 125°C	SOP8	A9151	3	Tape and Reel, 4000	Green
TPA9152-SO1R	−40 to 125°C	SOP8	A9152	3	Tape and Reel, 4000	Green

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

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