

## 275V Common Voltage Difference Amplifier

### Features

- Supply Voltage: 4.5 V to 36 V ( $\pm 2.25$  V to  $\pm 18$  V)
- Offset Voltage:  $\pm 1$  mV Maximum
- Gain Error: 0.03% Maximum
- Bandwidth: 500 kHz, Slew Rate: 10 V/ $\mu$ s
- EMI Enhancement
- $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  Operation Temperature Range

### Applications

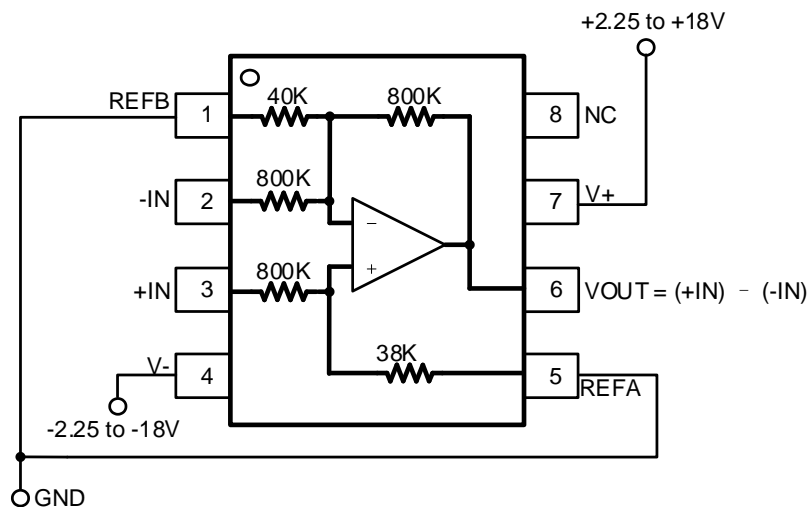
- Current sense on high common voltage
- Battery voltage monitor
- Industrial control

### Description

The TPA9151 is a general-purpose, unity-gain difference amplifier 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 device can be used to replace isolation amplifiers in applications if the galvanic isolation is not required.

### Typical Application Circuit



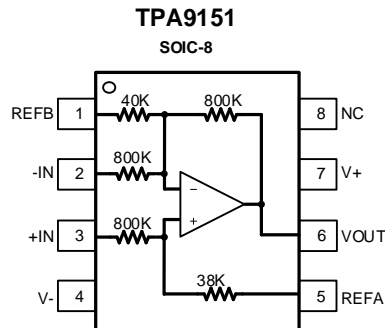
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## Revision History

Date	Revision	Notes
2021-07-20	Rev.A.0	Initial version
2021-08-31	Rev.A.1	Update description in ESD section

## Pin Configuration and Functions



## Pin Functions

Pin		I/O	Description
No.	Name		
1	REFB	Input	Reference input B.
2	-IN	Input	Inverting input.
3	+IN	Input	Noninverting input.
4	V-	Power Supply	Negative power supply <sup>(1)</sup>
5	REFA	Input	Reference input A.
6	VOUT	Output	Output
7	V+	Power Supply	Positive power supply <sup>(1)</sup>
8	NC		Not Connect.

(1) In this document, (V+) – (V-) is referred to as V<sub>s</sub>.

## Specifications

### Absolute Maximum Ratings

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
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

**Note:** 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 <sup>(1)</sup> , VOUT to V+ or V-, V+ to V-	4	kV
		ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup> , +IN or -IN to V+ or V-	1	kV
		ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup> , REFA	400	V
		ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup> , REFB	500	V
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 <sup>(2)</sup>	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	$\theta_{JA}$	$\theta_{JC}$	Unit
8-Pin SOIC	158	43	°C/W

**200V Common Voltage Difference Amplifier**
**Electrical Characteristics**

All test condition is (V+) = +15 V and (V-) = -15 V, R<sub>L</sub> = 10 kΩ to ground, REFA = REFB = GND, T<sub>A</sub> = 25°C, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Power Supply</b>						
V <sub>S</sub>	Supply Voltage Range		±2.25		±18	V
I <sub>Q</sub>	Quiescent Current	V <sub>OUT</sub> = 0 V		2	3	mA
		V <sub>OUT</sub> = 0 V, T <sub>J</sub> = -40°C to 125°C			3.5	mA
<b>Gain</b>						
	Initial	V <sub>OUT</sub> = ±10 V, R <sub>L</sub> = 10 kΩ		1		V/V
	Gain Error	V <sub>OUT</sub> = ±10 V, R <sub>L</sub> = 10 kΩ		0.02	0.03	%FSR
		V <sub>OUT</sub> = ±10 V, R <sub>L</sub> = 10 kΩ, T <sub>J</sub> = -40°C to 125°C			0.05	%FSR
	Gain Drift	V <sub>OUT</sub> = ±10 V, R <sub>L</sub> = 10 kΩ, T <sub>J</sub> = -40°C to 125°C		5		PPM/°C
	Nonlinearity	V <sub>OUT</sub> = ±10 V, R <sub>L</sub> = 10 kΩ		0.002		%FSR
<b>Offset Voltage</b>						
V <sub>OS</sub>	Input Offset Voltage	V <sub>CM</sub> = 0 V	-1	0.05	1	mV
		V <sub>CM</sub> = 0 V, T <sub>J</sub> = -40°C to 125°C	-2		2	mV
V <sub>OS</sub> TC	Offset Voltage Drift	V <sub>CM</sub> = 0 V, T <sub>J</sub> = -40°C to 125°C		2		μV/°C
PSRR	Power Supply Rejection Ratio	V <sub>S</sub> = ±2.25 V to ±18 V, V <sub>CM</sub> = 0 V, V <sub>DM</sub> = 0 V	90	120		dB
<b>Input</b>						
	Impedance	Differential		1600		kΩ
		Common-mode		400		kΩ
	Voltage Range	Differential	-13.5		13.5	V
		Common-mode, HTOL Test	-200		200	V
CMRR	Common-Mode Rejection Ratio	V <sub>CM</sub> = ±275 V, Production Test	80	90		dB
		V <sub>CM</sub> = ±275 V, Production Test, T <sub>J</sub> = -40°C to 125°C	78			dB
		V <sub>CM</sub> = 0 V to 60 V, TPA9151	80	95		dB
		V <sub>CM</sub> = 0 V to 60 V, TPA9151A	90	96		dB

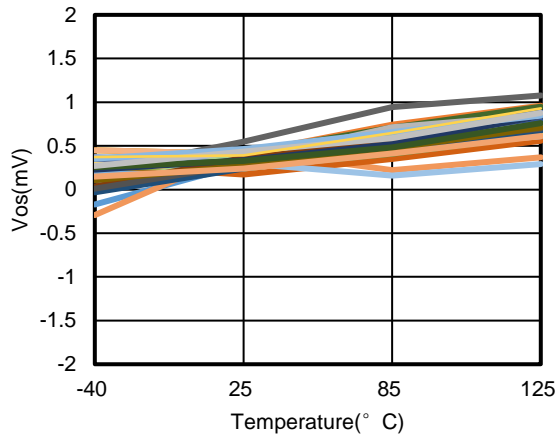
**Electrical Characteristics (Continued)**

All test condition is (V+) = +15 V and (V-) = -15 V,  $R_L = 10\text{ k}\Omega$  to ground, REFA = REFB = GND,  $T_A = 25^\circ\text{C}$ , unless otherwise noted.

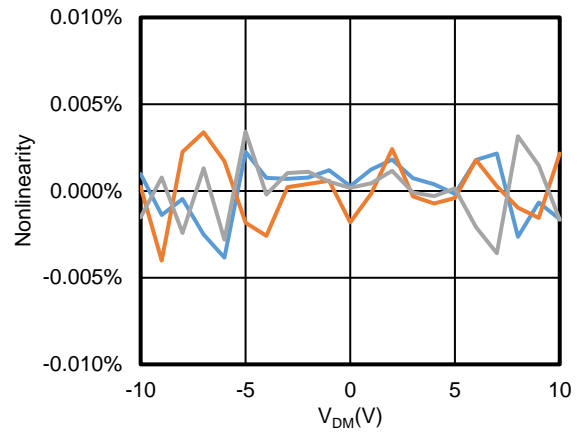
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Output</b>						
	Output Swing from Supply Rail	$R_L = 10\text{ k}\Omega$ to $V_S/2$		50	200	mV
		$R_L = 2\text{ k}\Omega$ to $V_S/2$		400	500	mV
Isc	Output Short-Circuit Current			100		mA
<b>AC Specifications</b>						
GBW	Gain-Bandwidth Product			500		kHz
SR	Slew Rate	10 V step		10		V/ $\mu\text{s}$

**Typical Performance Characteristics**

All test condition:  $V_S = 30\text{ V}$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.



**Figure 1  $V_{OS}$  vs Temperature,  $V_S = 30\text{ V}$ ,  $V_{CM} = 15\text{ V}$**



**Figure 2 Nonlinearity**



## Detailed Description

### Overview

The TPA9151 integrates on-chip matching resistors with high precision amplifier 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

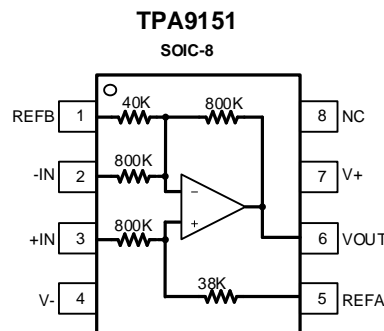


Figure 3 Functional Block Diagram

## Application and Implementation

### NOTE

Information in the following applications 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.

### Transfer Function

The complete transfer function of TPA9151 is given in [Equation \(1\)](#).

$$VOUT = (+IN) - (-IN) + 20 \times REFA - 19 \times REFB \quad (1)$$

Usually, REFA and REFB are tied to the same voltage level, and recorded as REF, so the transfer function is [Equation \(2\)](#).

$$VOUT = (+IN) - (-IN) + REF \quad (2)$$

### Basic Connections

Figure 4 Dual Supply Operation Connections shows the basic connections for dual-supply operation. Figure 5 shows the basic connections for single-supply operation. 0.1  $\mu$ F decoupling capacitors are recommended to be placed close to the power supply pins of the device.

## 200V Common Voltage Difference Amplifier

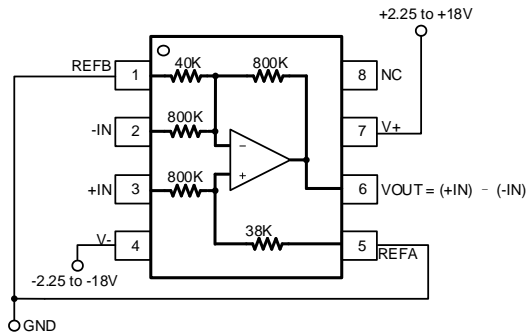


Figure 4 Dual Supply Operation Connections

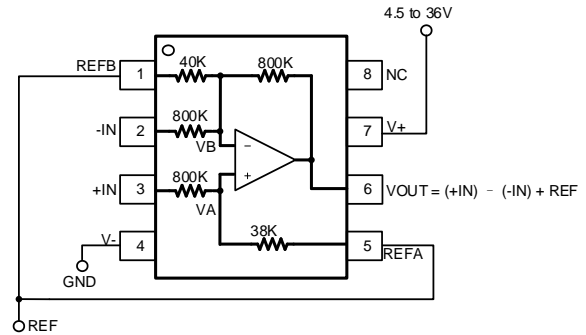


Figure 5 Single Supply Operation Connections

### Common Mode Input Range

The high common-mode range of the device is achieved by dividing down the input signal with 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. VA and VB are the inputs of internal operational amplifier in Figure 5, which can be calculated by the voltage at the (-IN), (+IN), REFA, REFB, (V+) and (V-) pin when the device works in the close loop. VA and VB can swing to negative power rail and 1.5V less than positive power rail, so the common-mode input range at the (+IN) input can be calculated by the [Equation \(3\)](#),

$$V_{CM} = (800+38)/38 \times (VA \text{ or } VB) - 800/38 \times REFA \approx 22 \times (VA \text{ or } VB) - 21 \times REFA \quad (3)$$

Some calculated cases are shown in Table 1, and please note that +275 V to -275 V voltage range is guaranteed by production test, +200 V to -200 V voltage range is guaranteed by HTOL test.

Table 1 Common voltage range with different supply voltage and reference voltage

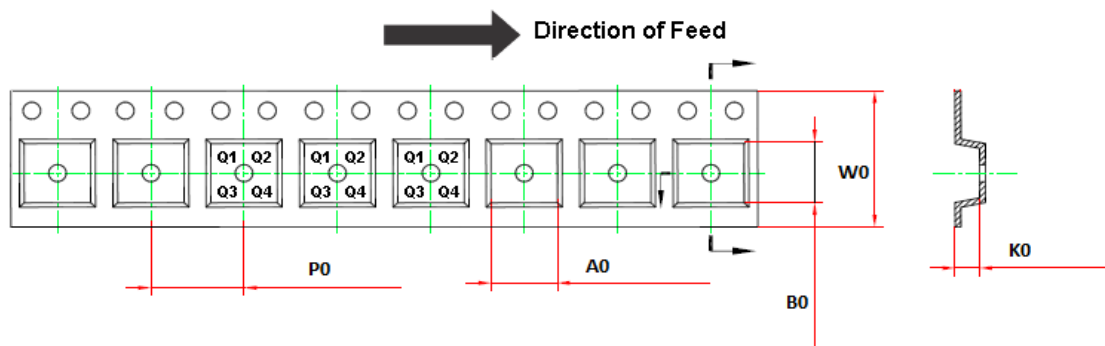
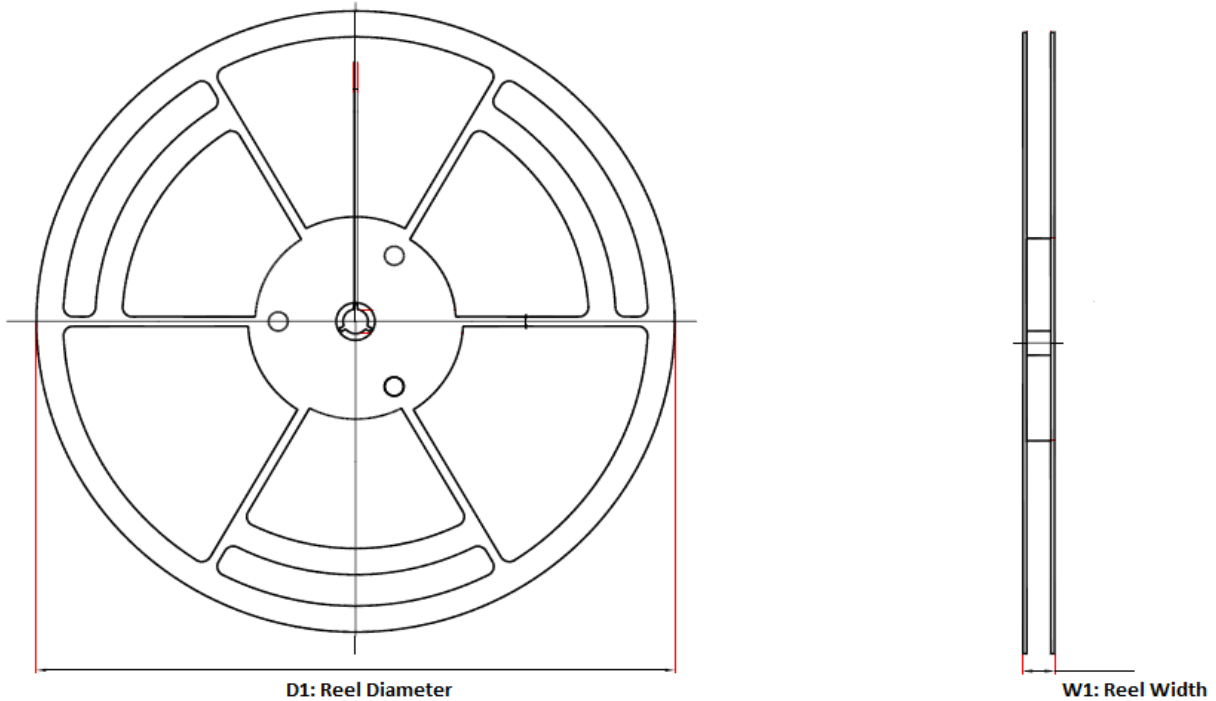
V+	V-	REFA	VA or VB		V <sub>CM</sub>	
			Min	Max	Min	Max
15	-15	0	-15	13.5	-330	297
30	0	15	0	28.5	-315	312
10	-10	0	-10	8.5	-220	187
10	0	5	0	8.5	-105	82

### Differential Input Range

When the voltage at the (+IN) pin is within the range calculated by the [Equation \(3\)](#), the voltage at the (-IN) pin can be determined by VOUT, REFA, REFB from [Equation \(4\)](#) which is derived from [Equation \(2\)](#). VOUT must be kept in the output range of internal amplifier. VOUT can reach negative and positive power rails.

$$(-IN) = (+IN) - VOUT + REF \quad (4)$$

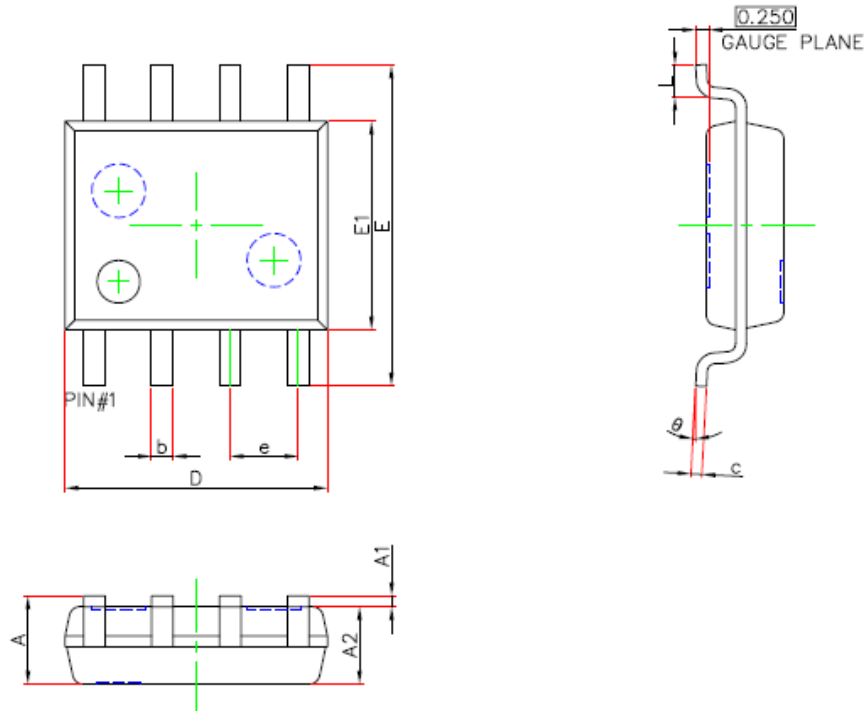
Tape and Reel Information



Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA9151-SO1R	8-Pin SOIC	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TPA9151A-SO1R	8-Pin SOIC	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1

Package Outline Dimensions

SOIC-8



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.450	1.750	0.057	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	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	0.800	0.016	0.031
$\theta$	0°	8°	0°	8°

## Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity
TPA9151-SO1R	-40 to 125°C	8-Pin SOIC	A9151	3	Tape and Reel, 4000
TPA9151A-SO1R	-40 to 125°C	8-Pin SOIC	A9151	3	Tape and Reel, 4000

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